John Strachan
1826

THE

ANATOMY AND PHYSIOLOGY

OF

THE HUMAN BODY.

CONTAINING

THE ANATOMY

OF THE

BONES, MUSCLES, AND JOINTS, AND THE HEART AND ARTERIES,

BY JOHN BELL:

AND

THE ANATOMY AND PHYSIOLOGY

OF THE

BRAIN AND NERVES, THE ORGANS OF THE SENSES, AND THE VISCERA.

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THE

ANATOMY

OF THE

HUMAN BODY.

VOL. III.

CONTAINING

THE ANATOMY

OF

THE ORGANS OF THE SENSES,

THE VISCERA OF THE ABDOMEN,

AND THE

MALE AND FEMALE PARTS OF GENERATION.

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ANATOMY
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INTRODUCTION.

ANATOMY

OF THE

VISCERA OF THE PELVIS.

EXPLANATION OF THE PLATES.

PLATE XXI.

THIS plate represents an ideal section of the abdomen, and the cut edge of the peritoneum is represented by the white line.

A. The LIVER.
B. The INTESTINES.
C. The KIDNEY.
D. The BLADDER of URINE.
E. The RECTUM.

1. The PERITONEUM, where it lines the abdominal muscles.
2. The PERITONEUM, where it is reflected to form the ligament of the liver.
3. The liver being represented cut through, we can trace the lamina of the ligament 2, over its surface 3, forming the peritoneal coat of this viscus.
4. Marks the PERITONEUM reflected from the liver upon the diaphragm.
5. Here the PERITONEUM is reflected off from the spine, to form one of the lamina of the mesentery.
6. The peritoneal coat of the intestine, which we can trace round the circle of the gut until it unites again with the mesentery.

7 7. The PERITONEUM, forming the lower lamina of the mesentery.

8. The PERITONEUM at that part where it is reflected, and covers the kidney.
9. The PERITONEUM is here descending upon the rectum E, we see it reflected over the gut, and descending again betwixt the rectum and bladder.
10. The PERITONEUM, where it forms a coat to the fundus of the bladder.
11. At this part we see the peritoneum reflected up upon the os pubis, and from that we trace it to fig. 1. Thus we see, that the peritoneum can be traced round all its various inflections and processes ; which shows, that it forms one continuous sac, and that the intestines and the liver are equally on the outside of this membrane with the kidney.

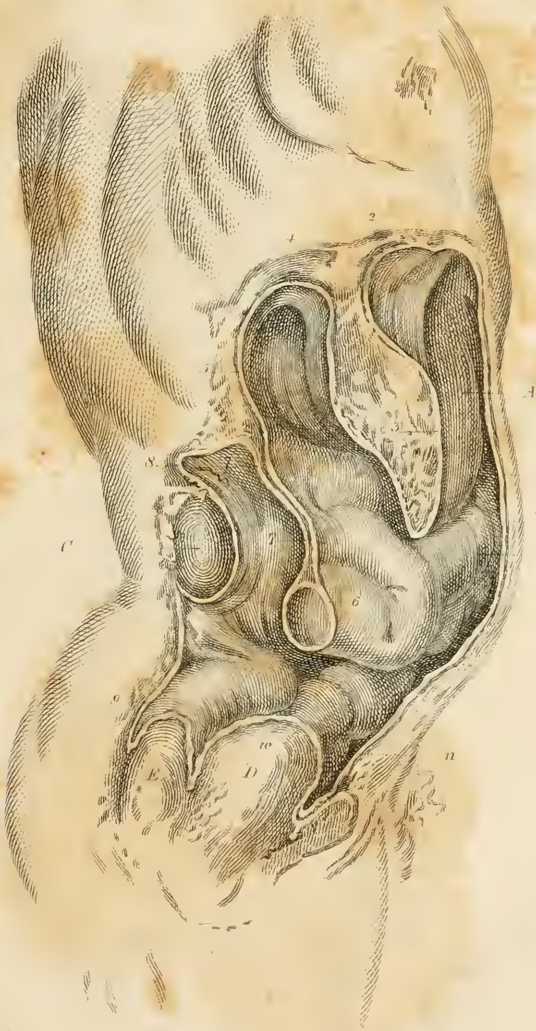
Explanation of Plate XXII.

This plate represents the epidydimis and testicle, injected with quicksilver, and dissected.

A. The body of the testicle with the tunica albuginea dissected off.
B B. The seminal vessels in the body of the testicle or TUBULI TESTIS.*

* Where the tubuli are emerging to form the rete vasculosum, or rete testis, they are called the *vasa recta.*

Plan Drawing of the Abdomen Showing the Inflections of the Peritoneum



Bell del.

Lenei sc.


F
E
E
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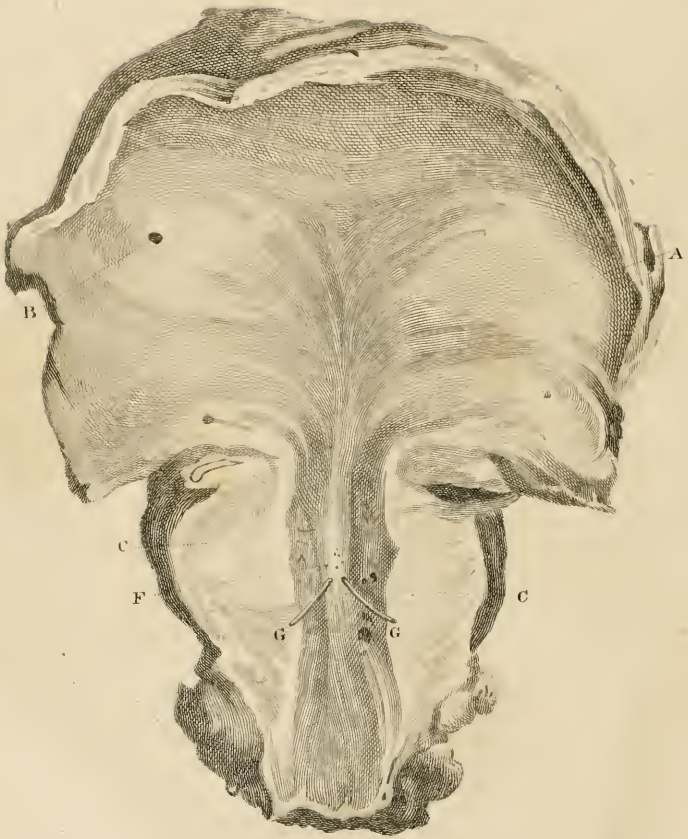


Bell del^t Lenoy sc^t

C. The RETE TESTIS formed by the union of the vessels B B.

D. The VASA DEFERENTIA, which as they proceed from the testicle, are convoluted in a conical figure, and are called the VASCULAR CONES.

E E. The EPIDYDIMIS formed of the union of the vascular cones; it is a little dissected and spread out.

F. The vas deferens.

Explanation of Plate XXIII.

This Plate represents the prostate gland, vesiculæ seminales, and lower part of the bladder, the parts being previously hardened in spirits, the vesiculæ were afterwards cut open.

A A. The body of the PROSTATE GLAND; it is that lower part of the gland which can be felt through the rectum.

B. The prostate gland is here cut into and dissected, in following the ducts of the vesiculæ.

C. The extremities of the ducts common to the vesiculæ seminales and vasa deferentia.

D D. The cells of the vesiculæ seminales, which are laid open by a section.

E. The left VAS DEFERENS, which is also laid open to show the cellular structure which it assumes towards its termination.

F. The RIGHT VAS DEFERENS.

G G. The foramina, by which the vasa deferentia open into the common duct.

H. The lower and back part of the BLADDER.

I. The RIGHT URETER.

Explanation of Plate XXIV.

This plate represents a section of the neck of the bladder.

A. The lower part of the urinary bladder near the neck.

B. The opening of the right ureter, which is marked 1. fig. iii.

C C. The substance of the prostate gland, which is cut through; its thickness, texture, and the manner in which it surrounds the beginning of the urethra, will be understood from this plate.

D. The URETHRA laid open.

F. The VERUMONTANUM, OR CAPUT GALINAGINIS.

G G. The points of feathers put into the openings of the vesiculæ seminales and vasa deferentia.

N. B. Round these ducts, on the surface of the verumontanum, and in that part of the urethra which is surrounded by the prostate gland, innumerable mucous ducts may be observed: into some of these small bristles are introduced.

Explanation of Plate XXV.

A view of the penis, vesiculæ seminales, and prostate gland.

Explanation of Plate XXVI.

FIG. 1.

An ovum in a very early stage, representing the shaggy surface of the true chorion.

FIG. 2.

We may see here the fœtus in a very early stage contained in the transparent amnion, and, attached to the outside of the amnion, the VESICULA UMBILICALIS.

N. B. These are not representations of the same abortion.

FIG. 3.

Represents the ovum a little more advanced.

A. The CHORION.

B. The AMNION.

C. The FŒTUS hung by the UMBILICAL CORD.

Explanation of Plate XXVII.

This plate represents two views of a conception, we shall say about the first month, and here the decidua and the ovum have been thrown off together. This abortion was prepared so as to resemble the beautiful engravings in Dr. Hunter's 34th table.

FIG. 1.

The deciduous efflorescence formed by the womb, is seen here entire, and seen as if moulded to the cavity of the womb: it is only necessary to observe that it hung inverted.

A. The lower part of the conception, which was near the neck of the womb, and which has some coagula of blood attached to it.

B B B. Quills introduced within the decidua by an opening near the neck of the womb, and their points brought out at that part of the membrane which answers to the opening of the Fallopian tubes: there it is either entirely deficient, or it is so thin that it has been torn at C C.

FIG. 2.

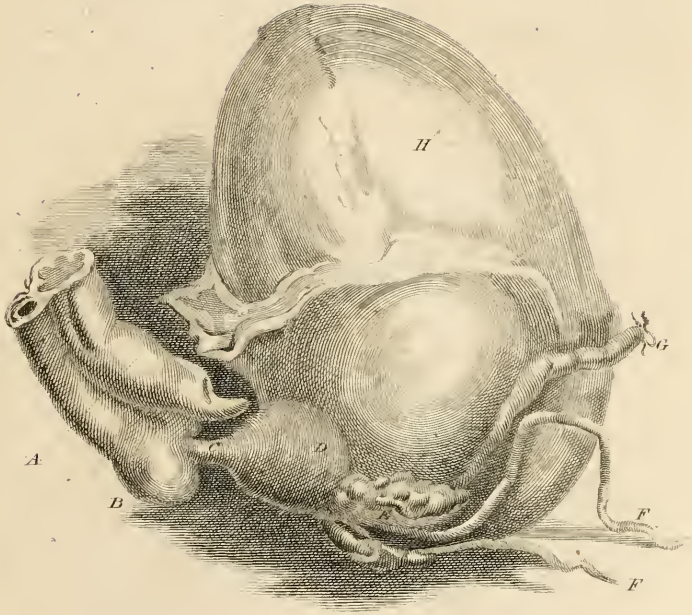
Here the other side of the conception is shown, and the ovum is seen to have adhered to the outer surface of the decidua.

A A A. The quills introduced into the cavity of the decidua.

B. The shaggy surface of the decidua.

C C. The fleecy outer surface of the chorion.

It is here to be observed that the ovum, C D E, may be supposed to be as it has descended from the ovarium, only



A. Crus penis
B. Bulb of the Urethra
C. Membranous p.t of the Urethra
D. Prostate Gland
E. Vesiculæ Semin
FF. Vasa deferentia
G. The Ureter
H. Bladder covered by the Peritoneum

Bell del. Lizars sc.

Fig. 1.

Fig: 2.

Fig: 3.

Lowry sc.

Fig. 1.

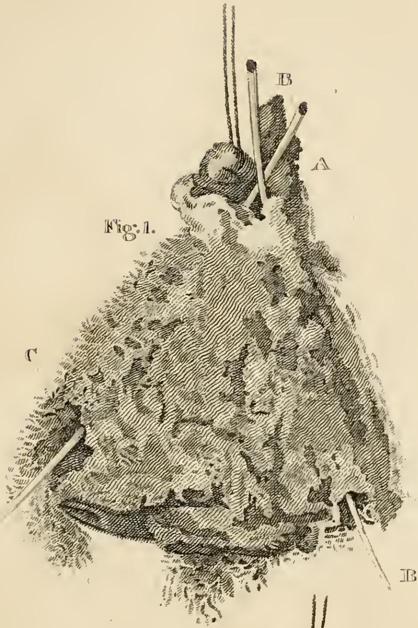
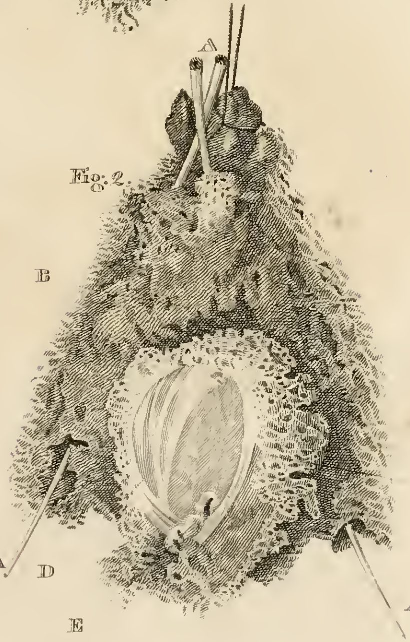


Fig. 2.



Bell del.t Lizars sc.

Published by Collins & Perkins 1810.

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somewhat enlarged, and it is here evidently on the outside of the decidua, but it has been torn open, and that deciduous surface which connected it to the surface of the womb at this place has been left with the womb, to be afterwards thrown off with the discharges.

D. The delicate membrane of the amnios.

E. The umbilical cord and part of the fœtus.

Explanation of Plate XXVIII.

This and the following plate represents a conception of the third month, and as the abortion was thrown off very entire, we have another opportunity of observing the state of the decidua in a more advanced state.

A. A thread passed through the more solid placentary mass suspending the whole.

B B. The DECIDUA, having a peculiar reticulated appearance.

C C. Shreds of the DECIDUA, where it has burst in the delivery.

D. The DECIDUA REFLEXA, through which also the proper membranes have burst.

E. The TRUE CHORION.

F. Very small curling arteries which are entering the decidua, or what may be considered as the maternal portion of the placenta.

Explanation of Plate XXIX.

We have here presented a view of a section of the same conception.

A. The DECIDUA.

B B. The cut edge of the DECIDUA, which will be seen to surround the whole ovum, and particularly it may be observed to form on the upper part a distinct lamina from the placenta F.

C C. The DECIDUA.

D. The DECIDUA REFLEXA.

F. The PLACENTA already formed by the accumulated vessels of the chorion.

G. The CHORION towards the lower part of the womb; here, it may be observed, the fleecy vessels have disappeared.

H. The AMNION.

I. The umbilical cord twisted three times around the neck of the fœtus.

THE

ANATOMY

OF

THE NERVOUS SYSTEM.

CONTINUED.

OF THE SENSES.

INTRODUCTION.

THE Senses are those faculties by which the active principle within us has communication with the material objects by which we are surrounded. Through them we receive those simple sensations which are the first elements of our thoughts, and the means of developing all the powers of the understanding. The exercise of our senses, however, is familiar to us from so early a period, that we never think of attending to their first simple intimations: before we are capable of reflecting on the nature of the perceptions which the several senses convey, they are so complicated and distorted by habits and association, that observation comes too late for us to ascertain the simple progress of nature. Philosophy revives the natural feelings of wonder at the spectacle of the universe; but too often we follow the dictates of a creative imagination, and run into error and delusion in studying the operations of nature.

To one who looks upon nature with the calm and chastened delight which is the character of true philosophy, there is a conviction that such researches may be carried too far. Wherever he directs his attention, whether to the structure of the human body, the physiology of vegetables, or the phænomena of chemical science; whether he endeavours to comprehend the system of the universe, or pores over the minutiæ of natural history, he finds every where a limit placed to his inquiries; a line which no industry or ingenuity can enable him to pass. We

may please ourselves with conjecture beyond this limit, but we find that all our opinions on these subjects are merely a dream of something allied to the impressions of our gross senses. The agency of the senses, the intercourse betwixt mind and matter, and the influence of the will over the body, are mysterious, and, probably, inexplicable phænomena; yet we scruple not to explain them precisely and mechanically; we reduce them to the level of our own capacity in the same manner as we fabricate to ourselves the idea of a Deity by the combination of all human perfections. Yet when we imagine that we have discovered the secret of these mysteries, it is mortifying to find ourselves without any sign or language by which to communicate those great truths to the companions of our studies: we struggle for expression; and, as all our ideas upon such abstract subjects are derived from analogy, we express our opinions respecting the powers of the mind, or the manner in which we perceive the objects of the senses, in the same language, and by reference to the same notions, which belong to the sensations themselves. From this scantiness and inaccuracy of language, it unavoidably happens, that very different ideas of the operation of the senses are expressed by several men in the same terms; and in attempting to convey our ideas in language more precise and definite, we are insensibly led to materialize the faculties of the mind, and to make the operations of the senses merely mechanical. What other explanation can we give of theories, which suppose the nerves to be tubes carrying animal spirits, or containing an elastic ether; or which represent them as vibrating chords, and reduce all the variety of sensation to the difference of tension and tone? These are, indeed, what Dr. Reid calls them, "unhandy engines for carrying images."

Nothing has been undertaken in philosophy but entire systems, fathoming at once the greatest depths of nature. The custom has been, to frame hardy conjectures; and if upon comparing them with things there appeared some agreement, however remote, to hold that as fully sufficient. What chimeras and monstrous opinions this method of philosophising has brought forth, it would be more invidious than difficult to specify.

The principles of philosophising have been laid down on this basis, that on no account are conjectures to be indulged concerning the powers and laws of nature, but we are to make it our endeavour, with all diligence, to search out by experiment the real and true laws by which the constitution of things is regulated. In the subject now before us we have a very remarkable proof of the superiority of investigation by experiment over the lazy indulgence of conjecture; and I hope the

whole tenor of the following account of the senses will strengthen the conviction of the student, that it is only by assiduous study, and patient observation of nature, that he is to look for the attainment of knowledge in the medical profession.

The office of the brain and nerves is to receive the impressions of external bodies, by which corresponding changes and representations are made in the mind. We know nothing further than that, by the operation of the senses, new thoughts are excited in the mind. Betwixt the sensation excited in the organ of the external sense, and the idea excited in the brain, there is an indissoluble, though inexplicable, connection; the brain is not sensible, nor does the eye perceive, but both together give us the knowledge of outward things. But when the sensation is once received and communicated to the brain it is treasured there, and may afterwards be excited independent of the external organ: hence comes the term internal senses.

Though I treat professedly of the external organs of the senses only, it may be necessary here to say a few words on the internal senses. It appears that all sensations originate in the external senses or organs receiving the impressions of outward bodies. When this change influences the mind, we call it perception. Memory is the power of recalling these sensations, and imagination is the power of combining them. These are powers of the mind, which, by the constitution of our nature, are gradually acquired, and increased by exercise. In infancy, the perceptions are simple and transitory; the memory is perfected by degrees, and with the store of ideas the imagination is invigorated, but still it is kept limited to the idea received, not from, but in consequence of, the operation of the senses.

It is in the combination and reciprocal effects of the mental powers and of the impression on the external senses, that we are to find an explanation of the operation of attention. When the mental powers are led to the contemplation of an idea which assimilates easily with the sensation about to be presented by the external organ, the perception is quick and vivid; but when the mind is strongly impressed and occupied with the contemplation of past ideas, the present operation of the sense is neglected and overlooked. Thus, the vividness of the perception or idea, is always proportionate to the degree of undistracted attention which the mind is able to bestow on the object of sensation or of memory. In solitude and darkness, the strength of the memory in the contemplation of past events is increased, because there is no intrusion in the objects of the outward senses; and the deaf or blind receive some compensation for their loss in the increased powers which are

acquired by a more frequent and undisturbed use of the senses which remain, and a keener attention to the sensations which they present. On the other hand, when we are under the enchantments of a waking dream or reverie, our attention is wholly detached from the present objects of the senses; and in this state we may continue to read without understanding. This absence, in a certain degree, is common, natural, and by no means unpleasant: it is the exertion of the faculty of the mind. But it may become disease; for health of mind consists in the due correspondence betwixt the excitement on the outward sense and the operation of the mind thus roused by the external sense.

The mind (united to the body) suffers in the diseases of the body. In the debility of the body, in fever, in spasms, and pain, the faculties of the mind languish, or are roused to unequal strength or morbid acuteness. Sometimes the phantasms and internal sensations of things once received by the outward senses, become so strong in the mind, as to be mistaken for objects actually present. Such phrenzy or delirium arises from a disordered and acutely sensible state of the internal senses. These impressions being great in degree, hurry and bustle is in the countenance of the patient, and uncommon strength and violence in his actions, just as passion gives uncommon excitement to one in health, causing a disregard or forgetfulness of all besides. In health, however vigorous the force of imagination may be, there is still a conviction that the ideas which it presents are not realities, and the operation of the external senses preponderates in recalling the attention to what exists around us But when the internal perceptions become so strong as to be mistaken for realities, the effect is falsely attributed to real existences. It indeed sometimes happens, that this false perception is really owing to disease in the organ, a too vivid perception of things absent proceeding from an affection of the brain, and not from an impression on the outward senses.

There is still another degree or class of diseased sensation, consisting in the modification of the impression of objects which are actually present to the senses. This modification of things present (as when bodies actually at rest appear to be in motion) is not always occasioned by optical deception. Objects seem to turn round, and this we shall afterwards find to proceed from the insensible motion of the eyes; but this motion of the eyes is occasioned by the disordered state of the internal sensation; and the same feeling will be experienced if the eyes be shut. For example, when we turn quickly round on our heel until we become giddy, it would appear that there

is a disturbance of the usual order of sensation, and that the course of our impressions is reversed; for while our sensations were formerly directed entirely by the impression made on the outward senses, the sensorial impressions now draw after them a sympathetic motion of the external organs.

This inverted communication betwixt the mind and organs is better exemplified in the organ of speech. Thoughts excited in the mind are represented by the signs of these ideas in speech. There occurs, however, not unfrequently, a diseased state of these operations of the internal senses, in which the ideas excited in the mind cannot be associated with their appropriate expressions; and although the patient has a distinct idea of what he means to express, he cannot recollect the words which belong to it; so that, when he asks for one thing, he names another which has no connection with it. Of this he is perfectly sensible, and yet he cannot correct himself.

There are more frequent instances of diseased corporeal sensation in hypochondriacs. In them, the sensation of pain and unusual feelings are falsely attributed to parts in which there is really no affection; for these feelings there is no apparent cause: they proceed from a disordered state of sensation in which the usual course of the impressions is altered, so as to occasion the patient falsely to attribute his suffering to sound and healthy parts. Thus indigestion, the irritation of the bile, flatulency, colic, &c. often do not give the usual impressions, but the pains are attributed to outward parts. That there is sometimes an actual connection existing betwixt the external parts, to which these feelings are referred, and the internal organs, is evident from the fact, that pressure in the outward and sound parts has occasioned spasms in the internal organs. To such disordered transmission of the irritation of the internal parts we have to attribute the extravagant and ludicrous ideas which hypochondriacs entertain. In these people, there are diseases of parts, of the action of which, during their healthy state, (as I have already explained in the short introductory view of the nervous system,) we have no feeling nor consciousness, and over which the will has no power. But, although in the healthy state of the economy there is no immediate route by which any sensation from these organs can be transmitted to excite a mental perception, it may happen, that, in their diseased state, when sensations do arise which forcibly attract the attention, an obscurity in the feelings produced by their derangement occurs, insomuch, that the mind may be deceived in regard to the direction of the sensation conveyed from them.

During health, there are vicissitudes of consciousness, sense,

and voluntary motion, and of rest from voluntary exertion, insensibility, and oblivion of the past. This is true, however, only comparatively, and by a gross reference to degree; for even during natural sleep there is not a total oblivion of past perceptions, nor is there always a total unconsciousness of the present, as the senses are in part awake; some one train of ideas is present to the mind; and the lapse of time is observed. Even these perceptions are sometimes so streng as to be followed by voluntary exertion, and yet the patient remains asleep. Whatever conduces to take the excitement from the mind, or lessens the vivacity of its impressions, conduces to sleep. Thus, rest, stillness, and darkness, by excluding the most lively impressions conveyed by the senses; and hæmorrhagy and evacuations, by lessening the velocity of the circulation; and cold, by lessening the sensibility; induce sleep. Again, compression of the returning blood from the head, by giving it a slow languid motion, and by depriving the vessels of their freedom of action, also conduces to sleep; because, as formerly remarked, the powers and faculties of the brain must be renovated through the means of the circulation.

By long watching and fatigue, the body is brought nearly to a feverish lowness. By sleep, rest is given to the voluntary muscles, and an abatement of the vital motions ensues; the quiescent state of the muscles brings back the blood to the heart, with a slow, regular, and calm progression; the heart is restored to its slow and equable pulsation; the breathing becomes slower; and the wasted strength of the system is recruited.

We may define sleep to be a state in which the sensations are dull, the voluntary muscles inert, and the vital motions calm and regular. In dreaming, the sensations are dull and obscure, but the imagination more alive and active; unnatural sleep, or soporific diseases, may be characterised by the disordered imagination, and disturbed vital and voluntary motions. The vital actions, which are calm, slow, and equable, during natural sleep, become oppressed; the sensibility, which is gradually diminished upon the approach of sleep, but always capable of being roused by the senses, becomes quite oppressed; the voluntary muscles continue relaxed, as in sleep, or convulsed by irregular motions. In the oppression of the night-mare, we have the consciousness of sensation, but the power of motion is lost. In apoplectic diseases, the functions of the viscera proceed, and are but partially impeded; but when the circulation of the blood and play of the lungs are obstructed, the operations of the mind are not equally unconcerned in the paroxysm; thus in syncope, the sudden deple-

tion of the blood-vessels of the brain causes instant loss of sense and of voluntary motion.

If natural sleep is not profound, the imagination is awake; but there may be false perceptions, false judgment and associations, and disproportioned emotions; and if sensations are perceived, they do not produce the ordinary associations. If such a state of the intellectual functions occurs during the waking state, it becomes delirium. That this delirium is analogous to the perturbed state of the imagination during sleep, appears from the delirium in fevers uniformly showing its approach in the patient's slumbers only. It is a disposition to form false images and associations, which, in the beginning, the excitement of the outward senses has power to counteract, insomuch that a patient can be roused from delirium as he can be roused from sleep; but, by and by, the external senses lose their superiority, and their excitement is attended with unusual associations; they no longer convey impressions to the intellect, but become subservient to, and modified by it, and the judgment, which depends on the due balance of memory and imagination, is lost. In fever, the delirium is transitory; in low fevers, it is combined with a comatose state. In melancholy, the delirium runs upon one object chiefly, or trains of ideas, which refer to the patient's health and corporeal feelings. In madness, the variety is infinite; but chiefly consisting in a vitiated imagination and perverted judgment, with fierceness and increased power of corporeal exertion.

There are five organs peculiarly adapted to convey sensations to the mind; or, as I am more inclined to say, to rouse the faculties of the mind by exercising the internal organs of the senses in the brain; these may be considered as forming a medium of communication betwixt the external creation and the sentient principle within us; they are at the same time the bond of union betwixt sentient beings. These organs are called the EXTERNAL SENSES; viz. the sense of seeing, the sense of hearing, the sense of smelling, the sense of tasting, and the sense of touch. Was I willing to break in upon received opinions in an elementary book, I would say that there was a sixth sense, the most important of all, the sense of motion; for it is by a sense of motion that we know many of the qualities of outward things, as their distance, shape, resistance, and weight. Individually, these organs convey little information to the mind; but by comparison and combination, the simple and original affection or feelings received from them are associated and combined to infinity, and administer to the memory and imagination, to taste, reasoning and moral perception, the passions and affections, and every active power of the soul.

BOOK I.

OF THE EYE.

CHAP. I.

INTRODUCTORY VIEW OF THE PRINCIPLES OF OPTICS.

Light is a matter thrown out from ignited, or reflected from shining, surfaces; and which enters the eye, and impressed on that organ, gives the sensation of sight. The sun is the greatest source of light, and perhaps the original and only source. The minuteness and inconceivable velocity of light, the facility with which it penetrates bodies of the greatest density and closest texture, without a change of its original properties, makes it the source of the most wonderful and astonishing phænomena in the physical world.

The smallest stream of light which propagates itself through a minute hole, is called a ray; and, as rays of light pass through a uniform medium in a straight course, they are represented by mathematical lines. But light is not uniform in respect of colour; every part of a ray is not capable of exciting the idea of whiteness which the whole raises. White light is composed of different kinds of rays, which individually give the sensation; one of red, another of orange, a third of yellow, a fourth of green, a fifth of light blue, a sixth of indigo, and a seventh of a violet or purple.* These are named the prismatic colours; because, in the spectrum produced by making a ray of light to pass through a prism, these several colours are seen in the succession in which they are above enumerated. Each of these rays individually impresses the eye with its own colour; but when they all impress the eye at once, the sensation upon the organ of sight is a compound effect; no individual colour

* There is a fact not a little extraordinary regarding the emanation of rays from the sun, and which has been discovered in the present day, viz. that there are invisible rays, giving heat but no light, which are less refractable than the coloured rays; and that all rays, in proportion to their refrangibility, have less power of producing heat. See Herschel on the invisible rays of light. Phys. Trans. 1800, part ii. p. 284.

is presented, but that mixed light which is called whiteness, and which may be divided into its individual colours by passing it through a prism.

It is the nature of most bodies to absorb some of these rays of light and to reflect others from their surface; consequently, the colours of bodies depend upon the particular rays which are reflected from them, or upon the combination of such rays as are reflected from them; and a body appears of that colour of which the light coming from it is chiefly composed.

When a ray of light passes from a rarer to a denser medium, or from a denser into a rarer, it alters its course, if there be any obliquity in the original direction; but if it strikes from one medium to another perpendicularly into the surfaces, its original direction is not changed. If the ray passing from the air enters obliquely into glass or water, or any denser medium, it turns more towards the perpendicular; but if it passes through the glass and emerges again into the air, it resumes its original direction, diverging from the perpendicular. This effect of different mediums upon the ray of light, is called refraction; when a ray of light impinging upon a surface does not enter, it rises again to the angle of its incidence: and this is reflection.

The prism is a piece of glass of a triangular form; the inclined surfaces of which, when placed in the course of the ray of light, refract, and separate the several parts of the heterogeneous ray, and show its compound nature. If the sun be permitted to shine into a dark room through a small hole in the window-shutter, and the beam of light be made to fall upon a glass prism, it is, in passing through the glass, separated into its constituent parts; because the several coloured rays have different degrees of refrangibility, in the order in which I have already enumerated them. If the rays, after passing through the prism, be made to pass also through a convex glass, they are brought again to a point in the focus of that glass; and the effect of the whole colours thus re-united, is perfect whiteness. We might suspect that the beams of light were homogeneous, and that the degree of refraction gave different colours to the rays, were it not proved, that how much soever any of the coloured rays is further refracted, it does not change its nature: nor will rays suffer any change by reflection from bodies of different colours, for minium will appear yellow, green, blue, &c. according to the colour of the ray of light directed upon it.*

* It is found, that the coloured rays have not all the same power of illuminating objects; the orange ray possesses this property more than the red; the yellow more than the orange, &c.; and the maximum of illumination lies in the brightest yellow or palest green; nor do the several rays equally affect the thermometer. See Herschel's Exp. Phys. Trans. 1800, p. ii. p. 255.

As the impression of light remains some time upon the nerve of the eye, it gave Sir Isaac Newton the opportunity of examining, whether each coloured ray makes a distinct impression on the eye, or whether they so affect each other as to impress the sense of whiteness on the eye. When a burning coal is whirled in a circle the eye perceives an entire circle of fire, because the impression made by the coal in any point of the circle remains until the coal returns again to the same place, and renews the sensation. When all the varieties of colours are painted in a circle, and turned in the same way with the burning coal, they must each make their separate impression upon the optic nerve; but the general sensation is whiteness; or when the teeth of a comb are drawn across the stream of light issuing from a prism, the different colours are intercepted in such quick succession, that a perfect whiteness is the result of the mixture of impressions. There are many experiments which show that the inequalities of the refraction of light are not casual; that they do not depend upon any irregularity of the glass: on the contrary, it is proved, that every ray of the sun has its own peculiar degree of refrangibility, according to which it is more or less refracted in passing through pellucid substances, and always in the same manner: and, lastly, that the rays are not split and multiplied by the prism.

When a ray of light falls upon the surface of glass obliquely it inclines to a line drawn (through the point of incidence) perpendicular to the surface.

Fig. 1.

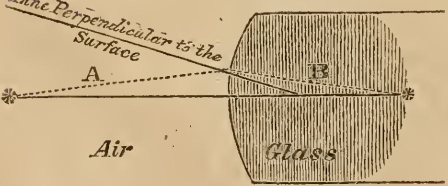
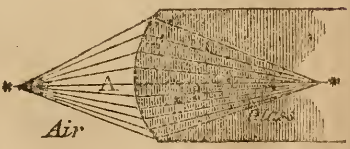


Fig. 2.



Thus the ray A, fig. 1, proceeding from the object, *, is refracted upon entering the mass of glass in the direction B, having a tendency towards the perpendicular line. By this means, if a number of rays proceeding from any one point, as in fig. 2, fall on a convex, or spherical surface of glass, they will be inflected so as to gather about the perpendicular line

A A in the centre of the glass: which perpendicular line is the axis of the glass. If the rays of light proceeding from an object be made to strike into a mass of glass with a concave surface, the obliquity with which they impinge upon the surface, being the reverse of the convex surface, they are not made to converge upon the central line, but diverge from it.

Farther, the rays of the sun, when passing from a medium of glass into the air, are turned, by refraction, farther off from the central line to which they were drawn in entering the convex surface of glass. But if the rays, in passing through the glass, were in a direction converging to the perpendicular line, they will be made to converge still farther, as is seen here in fig. 3.

Fig. 3.

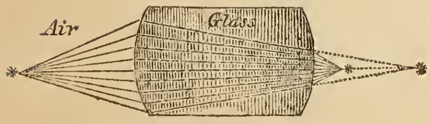
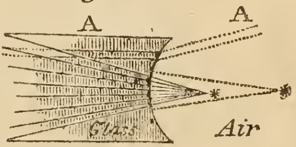


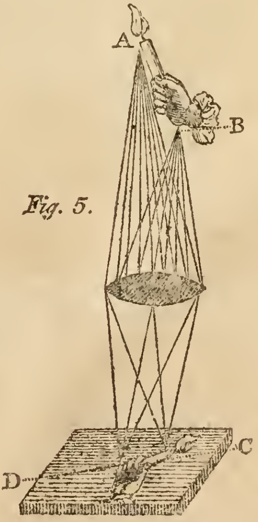
Fig. 4.



If, however, the rays be made to pass from glass into the air, and the surface of the glass be concave, as in fig. 4, the rays will be made to have a less degree of convergence, so as to remove the image * farther from the surface of the glass. But if the rays passing through the medium of glass have no convergence, but pass in parallel lines, they will diverge as the lines A A, fig. 4. do, when they emerge from the concave surface of the glass.

We see, then, the operation of a double convex glass, in forming the image of a luminous body upon a surface. If, for example, such a glass be held between a candle and a piece of white paper, (the distances being properly adjusted,) the image of the candle will appear very distinctly upon the opposed

Fig. 5.



surface, but inverted; because the rays coming from the point A fig. 5, converge at C, and those from the point B at D.

Before proceeding farther in this short exposition of the principles of optics, it will be necessary to take a very slight view of the structure of the eye.

INTRODUCTORY VIEW OF THE STRUCTURE OF THE EYE.

It is the first principle of the constitution of the eye, that the rays of light must be so concentrated as to impinge strongly on the expanded nerve or retina in the bottom of the eye. Now, as we have seen that a lens (which is a double convex glass) is necessary, so to concentrate the rays of light proceeding from an object, as to form a small and lively image of it (as in marginal plate, fig. 5.) so, in the same manner, an essential part of the eye is the lens, which brings the rays of light to a focus; and that the lens may make the rays proceeding from an object converge into an accurate focus, so as to form a distinct image on the eye, the vitreous humour is interposed betwixt the lens and the surface of the retina: again, it is necessary to the constitution of the eye, that, in order to increase the sphere of vision, the anterior part of it shall project and form a large segment of a small circle, so as to take a greater circumference into the sphere of vision than could have been done, had the larger sphere of the eyeball been continued on the forepart. Another necessary part of the apparatus of the eye is the iris, which is a curtain in the anterior chamber of the eye, perforated with a hole, which is capable of being enlarged or diminished so as to admit a larger or smaller stream of light according to the intensity of the light. In this provision, we see the necessity of the anterior humour of the eye being different from the others; being merely an aqueous secretion, while the others possess a degree of firmness, viz. that the iris or curtain of the eye, may move with perfect freedom in it.

Fig. 6.

The three humours of the eye are thus situated, and have this general character:

1. The AQUEOUS HUMOUR is the anterior humour of the eye. It distends the anterior and pellucid part of eye, so as to increase the sphere of vision. It is perfectly fluid, and of a watery consistence, that it may allow free motion to the iris.

2. THE LENS OR CHRYSTALLINE HUMOUR is placed immediately behind the perforation in the iris; which perforation is called the pupil. The lens collects the rays of light like a double convex glass, so as to concentrate them, and make a more forcible image on the bottom of the eye.

3. The VITREOUS HUMOUR is behind the lens. It distends the general ball of the eye into a regular sphere, that it may move easily in the orbit; and its diameter in the axis of the eye is so proportioned to the focal distance of the lens (affected also in some degree by the other humours) that the image of an object is formed accurately on the surface of the retina; accordingly, when the coats are cut from the back of the eye, the picture of a luminous object held before the pupil is seen exquisitely minute and distinct on the botom of the eye.

While these humours have each its distinct character, they possess in proportion to their density, different powers of refracting the rays of light. This has the still farther good effect of correcting the aberration of the rays, and giving the truest colours, as well as the most correct image of the object presented to the eye.

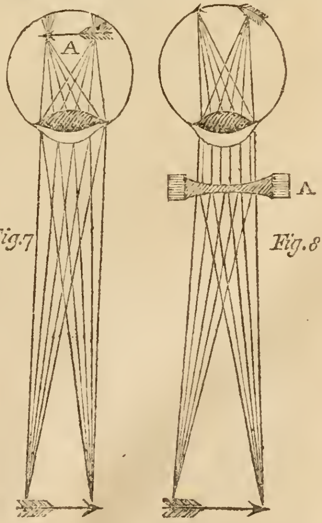


Fig. 7 Fig. 8.

If the lucid anterior part of the eye be formed too prominent, or if the lens of the eye have too great a degree of convexity, or, lastly, if the size of the ball of the eye, and the diameter of the vitreous humour in the axis of the eye be unusually great, then the person does not see distinctly; because the powers of the humours, in concentrating the rays of light, are too great, and the image of the object is not formed accurately on the retina, but before it. Thus, in fig. 7. the convexity of the cornea, the lucid anterior part of the eye, or the focal powers

of the lens, being too great for the length of the axis of the eye, the image is formed at A before the rays reach the surface of the retina; and after coming accurately to the point, they again begin to diverge; which diverging rays, striking the surface of the retina, give the indistinct vision of a near-sighted person. But as this indistinctness of vision proceeds from no opacity, but only the disproportion of the convexity of the eye to the diameter, the defect is corrected by the concave glass, A, fig. 8; for the effect of this glass being the reverse of the convex, it causes the rays to fall upon the surface of the eye, so far diverging from the perpendicular line, (which is exemplified in fig. 1.) as to correct the too great convergence caused by the convexity of the humours. But, when a near-sighted person has brought the object near enough to the eye to see it distinctly, he sees more minutely, and, consequently, more clearly; because he sees the object larger, and as a person with a common eye does, when assisted with a magnifying glass or convex lens.

The near-sighted person sees distant objects indistinctly; and as the eye, in consequence, rests with less accuracy upon the surrounding objects, the piercing look of the eye is diminished, and it has a dulness and heaviness of aspect. Again, the near-sighted person knits his eyebrows, and half closes his eyelids: this he does to change the direction of the rays, and to correct the inaccuracy of the image, in a manner which may be understood by the following analogy. If we make a card approach a stream of light passing through a window, it will so attract the rays of light, as to extend the margin of the figure of the circular spot of light upon the wall. In the same way, when a stream of light, proceeding from an object towards the eye, is made to pass through a small hole, the circular margin of the hole so attracts the rays, as to produce the same effect with the concave glass; by causing the rays to take a direction outward, as if proceeding from a nearer object, the image is carried farther back from the lens; and when a near-sighted person peers through his eyelids, it makes the rays impinge accurately upon the retina.*

The effect of old age, is gradually to reduce the eye to a

* Short-sightedness may be produced by accidents. Once I have known it produced by a piece of glass sticking in the cornea, and causing great inflammation. Dr. Briggs mentions the case of an old man, who had long used spectacles, becoming suddenly short-sighted by catching cold, and he was afterwards enabled to read the smallest print without glasses. In general, however, it is by some accident, and often not till manhood, that we become sensible of being short-sighted; and, then men are very apt to attribute the defect to some particular occurrence.

less prominent state, and, consequently, to bring it to the reverse of the near-sighted eye.

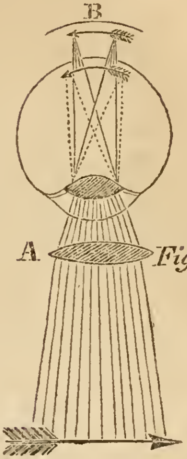


Fig. 9.

From the decrease of the humours, and the lessened convexity of the cornea, the image of objects is not formed soon enough to impinge accurately on the retina, the rays tend to form the image behind the retina, as we see in fig. 9.

In this figure, we have the effect of old age on the humours represented: without the intervention of the glass A, the rays have a direction which would form the image at some distance beyond the retina, as at B. But by the convex glass A (which is of the nature of the common spectacles for old people) the direction of the rays of light is so corrected, that the image falls accurately on the bottom of the eye.

We understand, then, whence these opposite defects of sight arise; that, in old people, objects cannot be seen distinctly when near, and, in short-sighted people, they cannot be seen distinctly when at a distance. We see, also, why old age corrects short-sightedness by gradually reducing the convexity of the eye, enabling the person to see objects farther removed, until, by degrees, he comes to see perfectly at the distance most convenient for the common affairs of life.

It has been, by some, thought extremely difficult to account for the image appearing to us, as it is in nature, erect, since it is actually figured on the bottom of the eye in an inverted posture; but the terms above and below have no relation to the image in the bottom of the eye, but to the position of our bodies and the surrounding things. When I look to a tall man's face, I direct my eyes upwards; I observe his situation, as it relates to an ideal area before my eyes, or to a space in the sphere of vision.

When an object approaches towards the eye, the diameter of the picture on the retina increases in the same proportion as the distance between the eye and the object decreases: and, consequently, it decreases in the same proportion as the distance increases. But the degree of brightness of the picture of an object on the retina continues the same at all distances, between the eye and the object, unless some of the rays of light are interrupted in their progress; for,

as the advancing object becomes bright, it increases doubly in length and breadth, or quadruply in surface. The faint appearance of remote objects, therefore, is occasioned by the imperfect transparency of the atmosphere.

There is nothing more astonishing in the structure of the eye, than the sensibility of the expanded nerve, as proved by the extent of the changes or degrees of light which illuminate visible objects; or the great degree of light which the eye can bear, and the low degree of light at which objects are visible. Thus, the proportion betwixt the degrees of light illuminating an object by the sun, and by the moon, at any equal altitudes, is calculated at 90,000 to 1.* Again, by M. de la Hire's calculation, we see the sail of a wind-mill, six feet in diameter, at the distance of 4000 toises. The eye being supposed to be an inch in diameter, the picture of this sail, at the bottom of the eye, will be $\frac{1}{8000}$ of an inch, which is the 666th part of a line, and is about the 66th part of a common hair. This gives us an idea of the minuteness of the structure of the optic nerve, and the extent in the degree of impression of which it is susceptible. It is evident that some guard to the eye must be furnished, in order that the organ may accommodate itself to this variety in the intensity of impression.

The pupil of the eye is formed by the central perforation in the iris or curtain, which hangs before the lens. This body having muscularity, is moveable; it dilates or contracts the hole or pupil, transmitting the rays so as to adapt the diameter of the stream of light, darting into the eye, to the intensity or degree of light. If a body is illuminated but faintly, the pupil is (insensibly to us) enlarged, and a greater quantity of the rays are allowed to be transmitted to the retina. But as the convexity of the pellucid part of the eye, and the concentrating powers of the lens, remain the same, the size of the image is not altered by this dilatation of the pupil, but only the strength of the image or picture in the bottom of the eye is increased.

We understand that the rays of light are refracted, when they pass out of one medium into another of different density. For example, the rays of light are refracted towards the perpendicular line, when they enter the cornea of the human eye; but they will be refracted in a very small degree in entering the cornea of fish, because the aqueous humour is of the same density with the fluid from which the rays of light are transmitted; accordingly, the cornea of fishes is not prominent: this would limit their sphere of vision, were not the flatness of the cornea counteracted by the prominence of the whole eye,

* See Smith's Optics, vol. i. p. 29.

and the more anterior situation of the chrystalline lens; a large pupil and long diameter of the eye we shall afterwards find to be necessary to the distinct vision of fishes.*

It is natural, on the present occasion, to inquire into the effects of the several humours of the eye, in producing in those who are short-sighted the obscurity arising from the double appearance of small and shining points. This is prettily explained in Jurin, upon Sir Isaac Newton's principle, concerning the fits of easy refraction and reflection of light.

The horns of the new moon, or the top of a distant spire, or the lines upon the face of a clock, appear double or triple, and sometimes much more multiplied, to a short-sighted person. The same appearance will be given when an object is held too near the eye, for perfect vision. If the light is seen through a narrow slit in a board, and the board is brought nearer to the eye than the point of distinct vision, the aperture will appear double, or as two luminous lines, with a dark line between them; and as the distance is varied, two, three, four, or five dark and luminous lines will be observed. There are many such deceptions in viewing luminous bodies; all of them proceed from the same cause, which is this:—Before Sir Isaac Newton's philosophy was acknowledged, it was the received opinion, that light was reflected from the surface of bodies by its impinging against their solid parts, and rebounding from them like a tennis-ball when struck against a hard and resisting surface: further, as they saw that part of the rays of light were in glass reflected, and the rest transmitted, they conceived that part entered the pores of the glass and part impinged upon its solid parts. But this does not account for the refractions which take place when the rays have passed the glass, and are about to be transmitted into the air; they cannot find solid parts to strike against in entering the air, for the refraction of the light is greater in passing from the glass into the air, than from the air into the glass; and if water be placed behind the glass, the refraction of rays passing out from the glass is not increased, but diminished, by this substitute for the rarer medium of the air. Again, when two glasses touch each other, no refraction is made in rays passing from the one into the other. To explain this, Sir Isaac Newton taught,

* Neither fish out of water, nor other animals within water, can see any object distinctly. Divers see objects as an old man would do through a very concave glass put near to the eye: and it has been found that the convexity of spectacles for divers in the sea must be that of a double convex glass, equal on both sides to the convexity of the cornea. The necessity of this is plain; the aqueous humour of the eye being of the same density with the water, there is no refraction of the rays in passing from the water into the eye, and this deficiency must be supplied.

that in the progress of rays of light, there is an alternation of fits of easy transition or reflection; or, in other words, that there is a change of disposition in the rays, to be either transmitted by refraction, or to be reflected by the surface of a transparent medium. Jurin illustrates this opinion, and its application to our present purpose, in this manner.

Suppose that A B D, and B D F, are mediums of different density, and that their surfaces are intersected by the line B D; again, let A be a pencil of rays, which, issuing from this point falls upon B *a* D, as the refracting surface B *a* D is convex, and no two points of it, from *a* to D, are equally distant from the source of the rays A; and as the rays of light, in their progress, alter alternately from the fit of refraction to the fit of reflection, they must be in part refracted to the focus F, and reflected in the direction of the dotted lines C *e*. Thus, if the ray A *a* happens to be in disposition to pass through the medium B D F, it will pass on towards the point F. If the next ray A *b* should be in no fit to be transmitted, because, being in a degree farther advanced from its source A, it has changed to the fit of reflection, then it will not be refracted towards the focus F, but reflected off towards C; but again the ray A D being advanced farther from its source, it will impinge upon the surface B D, during its disposition to refraction, and will concentrate its beams at F; and so with all the others, alternately reflected and refracted.

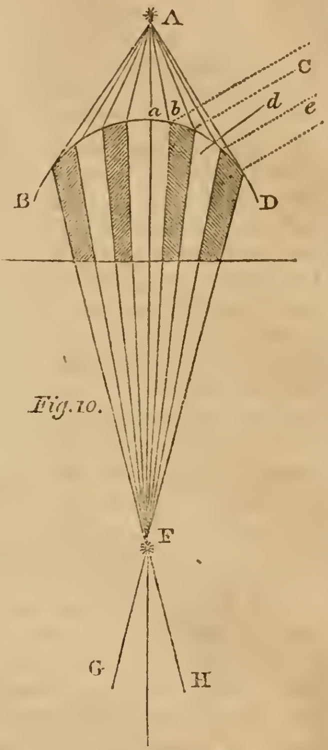


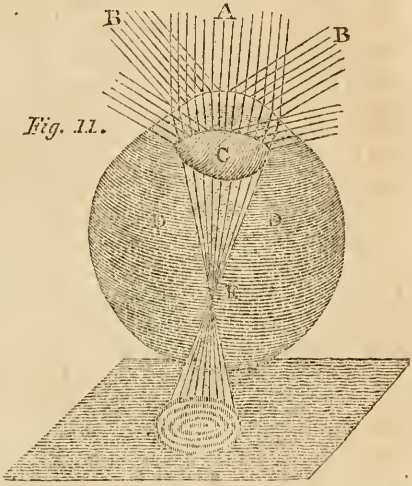
Fig. 10.

The consequence of this obstruction to the equal refraction of light is, that the image formed at F is feeble; but still it is distinct and perfect; because the transmitted rays are regularly concentrated, and form the proper focus. But if the converging rays should be received upon a plain before they arrive at the focus F, the reflected rays of light will have left spaces dark where they would have fallen by refraction, and,

consequently, distinct luminous circles will be thrown on the plain: again, if the plain surface be opposed to the rays, after they have formed their focus, and are again dispersing after having crossed, the same unequal effect of light and dark circles will be thrown on it; though now, the rays of the right side of the pencil B D F, will form the left of the pencil F G H.

How the changeable state of the rays produces the indistinctness of the near-sighted eye, may be understood from this (11.) diagram.—When the rays A strike the convex surface of the cornea, part of them will be reflected from the surface of the cornea, in the direction of the lines B B, when they will consequently strike upon the convex surface of the lens in luminous rings, these rings will be still farther multiplied and diminished in diameter, in being in part transmitted, in part reflected, from the surface of the lens C, and vitreous humour D D. These effects of the alternate disposition of the rays for transmission and reflection would not be perceptible, did the converging powers of the cornea and lens bring the focus of the rays exactly to the surface of the retina; but as the focus is formed at E, some way before the retina, the rays have decussated and spread out again before they form the image upon the bottom of the eye. Instead, therefore, of forming an accurate image, they are spread out into concentric circles; or in a lesser degree, the person experiences a confused outline of the object, which becomes surrounded with several rings or false outlines.*

Fig. 11.



* By *fits of easy transition*, it was not meant by Sir Isaac Newton that the rays must necessarily be transmitted through every pellucid medium, and at any obliquity of incidence, but only that the ray was more easily transmitted, and more difficultly reflected; nor was it meant that, during its *fit of easy reflection*, it was absolutely incapable of being transmitted, but only more readily reflected than transmitted.

CHAP. II.

OF THE COATS OF THE EYE.

THE coats of the eye are to be divided into three classes.

1. The anterior and external coats, viz. The CONJUNCTIVA and the ALBUGINEA.

2. The proper coats, viz. The SCLEROTICA, the CHOROIDES, the RETINA..

3. The transparent tunics of the eye.

As the first class belongs to the external apparatus of the eye, we shall begin with the PROPER COATS.

Speaking generally, and without considering the minuter divisions of anatomists, we may say, that there are three proper coats of the eye, viz. the SCLEROTIC COAT, giving strength; the CHOROID COAT, being the vehicle of the chief vascular structure of the eye; and the RETINA, or expanded nerve, being the organ itself. These are the proper coats of the eye.

Although many of these coats may be capable of being divided by the art of the anatomist, either by the knife, by injections, which form extravasation between their layers, by maceration, or by the chemical action of fluids; yet it is better, in a general enumeration, to take a natural division and character, than to enumerate their several lamina.

OF THE SCLEROTIC COAT.

THE sclerotic coat is so called from its hardness.* The sclerotica and cornea are often considered as one continued coat investing the eye; hence they say, the opaque and the lucid cornea. But, although these parts are actually in union, yet as they are really of so very different a nature, we must consider them apart, and treat at present only of the opaque white sclerotic coat.

The sclerotic coat is a strong, firm, and white membrane, consisting of lamellæ firmly attached and interwoven, and not capable of being regularly separated by maceration; it has the denseness of tanned leather. In firmness, whiteness, opacity, and the little appearance of vascularity, it more resembles the dura mater, than any other membrane of the body.

In adults, the sclerotic coat is stronger and firmer, comparatively, than in the fœtus; the cornea less so. On the outer

* Dura seu sclerotica; Vesalius, Ruysch, &c.

surface, it has (towards the orbit) a loose cellular membrane attached to it, which allows the motion of the eyeball. Upon the fore part it is invested by the tunica albuginea or tendinea. Upon its inner surface, it has a loose and soft membrane which connects it with the choroid coat.

In birds, and the tortoise, the posterior part of the sclerotic coat is thin; the fore part of it is split into laminæ, betwixt which there are interposed thin plates of bone,* while in fishes it is in part cartilaginous,† but thin and transparent, so that there appears a very beautiful spotted coat beneath it. There are also seen in the sclerotic of fishes little white granules like glands.

The vagina of the optic nerve can be separated into two laminæ;‡ the outer one is observed to unite intimately with the outer part of the sclerotic coat, while the inner lamina of the vagina is contiguous with its inner surface. The pia mater, too, says Zinn, when it has pierced the foramen in the sclerotic coat, along with the substance of the nerve, expands upon the inner surface of this coat, and extends even to the cornea, and forms one of its intimate laminæ. This must be only that part of the pia mater which invests the optic nerve, or, more strictly speaking, that membrane which stands in the same relation to the nerve, that the arachnoid coat does to the brain; for the membrane, which sinks into intimate union with the nerve, accompanies it even in forming the retina.§

The sclerotic coat is the great support of the globular figure of the eye; it defends the more delicate internal structure from slighter injuries, by its strength; and from the progress of inflammation, by being of a structure but little vascular, and not prone to disease. That inflammation which we see to be so frequent in the eye, is not in the sclerotica, but in the adventitious coat, the conjunctiva. But in proportion as the sclerotic

* Cuvier, vol. i. p. 387.

† Morgagni Epist. An. xvi. 40. Cuvier, 388.

‡ Ruysch, Zinn.

§ It may be well, in this place, to mention the opinions of the chief supporter of that scheme of the coats of the eye, which derives them all from the investing membranes of the brain and optic nerve. M. le Cat, in his *Traité des Sens*, describes them thus:—When the optic nerve has entered the orbit, the dura mater which surrounds it, splits into two laminæ; the external one attaches to the orbit, and forms the periosteum, the other forms the vagina of the nerve. In the angle formed by these, the muscles of the eye arise. This continued sheath of the nerve (he continues) expands into the globe of the eye, as the mass of glass is blown into a bottle. The dura mater of the nerve is expanded into the cornea (viz. sclerotica.) The second envelope, or pia mater, forms two laminæ; the one is applied to the sclerotic coat, and the other forms the choroid coat. The choroid coat divides anteriorly, and forms the iris and ciliary processes. The internal medullary part of the optic nerve forms the retina. Finally, "L'œil est tres evidemment l'extremité nerveuse epanouie boursouflée en bouton creux & plen de liqueurs," p. 158. See also *Bonn* Sandifort Thesaur. de continuatione membranæ.

coat resists pressure and the progress of disease from without, it resists the swelling of the parts within when they become diseased, and gives the greatest torture.

Of what importance the entireness of the coats, and the uniform resistance of the humours of the eye is to the healthy state of the organ, will be afterwards examined.

OF THE CORNEA.

The cornea is so called, from being firm, transparent, and composed of laminæ.* It is the pellucid circle on the fore part of the eye, which seems variegated with colours; though this is a deception, owing to its perfect transparency. The circle of the cornea is, however, far from being regular; its margin is flat towards the nose.

The cornea consists of laminæ; betwixt which, there is interposed a cellular substance, filled with a perfectly pellucid fluid.† These cells seem, like the common cellular membrane of the body, to have a free communication with each other, so that the fluid freely exudes, and as quickly is imbibed by maceration. The fulness of the cornea, with the perfect transparency of the fluid, gives a brilliancy to the eye, and is a sign of health; the reverse dims the eye, and with the fallen features, accompanies ill health. Steno observed, and Petit confirmed, the fact,‡ that the pores on the surface of the cornea exuded the fluid which fills the cells of the cornea; and that, after the surface was carefully dried by pressure, the moisture might be seen to form in drops upon the surface. The moisture can be thus forced out from the pores of either surface of the cornea.§ This moisture becomes dull and clammy on the approach of death, and forms sometimes a pelicle over the cornea. The laxity with which the laminæ of the cornea are connected may be, in some measure, demonstrated, by taking it betwixt the finger and the thumb; we shall then find, that the layers can be made to glide very freely on each other. In the fœtus, and in young children, the cornea is of great thickness, and resists the point of the lancet or scissors. This resistance in the fœtus proceeds from a great degree of toughness, while, in the adult, the surface of the cornea is so hard, that I have often seen the point of the knife, in extracting the cataract, bend upon it. This turning of the elastic point of the knife is very apt to give a wrong direction to the incision; and, indeed, this occurred to me in my first operation.

* "Cornumodo, dura, & cornu instar in laminas dividareque potest." Vesalius

† Substantia spongiosa Valsalvæ.

‡ See also Hovius, p. 82.

§ Zinn.

There is a pelicle, or exceedingly thin coat, which, by maceration, can be taken off from the surface of the cornea. This is the conjunctiva continued over it.

The membrane in fishes, analogous to the adnata, lies loose over the cornea; and, in serpents, it is thrown off from the cornea, with the scales of the body, and remains attached to the cast skin of the head; and in the fœtus calf, I have forced the blood in the vessels of the conjunctiva into the vessels passing over the surface of the cornea.

By maceration, I have found, raised in the fluid, a very delicate and transparent membrane from the inner surface of the cornea;* and, after long continued soaking, the whole cornea can be taken out of the sclerotic coat, like an optician's glass from its frame.

The cornea possesses great sensibility; although much of the pain, from hard bodies flying into the eye, is to be attributed to the motion of the eyelids, and the great sensibility with which they are endued. When a splinter of glass or metal strikes and sticks in the cornea, inflammation is excited; in consequence of this, vessels carrying red blood strike into it, or shoot over its surface in a new film of membrane.† Petit thought he observed first in a negro, and afterwards in a variety of instances, red lines in the cornea; which he conceived to be the anastomosing of vessels. There are, besides, says he, many circumstances which argue that there are blood-vessels in the cornea. When the eye receives a stroke, there is often blood effused in its substance; abscesses, also, are found within it, and phlyctænæ are seen on its surface; and in great inflammation of the eye, the cornea appears red; which, he supposed, must be produced by the same cause, which makes the albuginea red, viz. the enlargement of its vessels, and the circulation of red blood. But we must not imagine, he continues, that, in the natural state, red blood circulates in the cornea; for the vessels are not to be seen with the microscope; nor are they penetrated by injection; nor do they appear in the fœtus; nor, when little abscesses are formed in the cornea; but only when violence has been done by a stroke upon the eye. In an eye in which the tunica conjunctiva was most minutely injected, as well as the internal vessels of the eye, I had resolved carefully to examine the structure of the cornea; and after a long mace-

* This, within these two years, has been claimed as a discovery. I fear that this must be considered as the capsule of the aqueous humour, long since described.

† I have found the spark from iron, in blacksmiths and masons, buried in the cornea for several days (some authors say months,) without exciting pain or much inconvenience. I have also more than once picked a little black slough from the cornea, mistaking it for a piece of iron, when it was only the consequence of the injury.

ration, in which it had greatly swelled, I observed a set of vessels totally distinct from the extremities of the minute blood-vessels. The minute blood-vessels which were injected, stopt abruptly on the margin of the cornea. But these I now mention are particular; they are in great profusion, large, and perfectly pellucid; they are large towards the middle of the cornea, and diminish towards the margin. Their free communication formed a net-work deep in the thickened substance of the cornea. The size, perfect pellucidness, and intimate connection of these vessels, might perhaps incline one to call this a cellular structure.

Vessels attach themselves both to the inner and to the outer surface of the cornea; and when it becomes spongy and vascular in this way, little can be explained of its natural structure. Thus, the pannus and pterygium are membranes which stretch across and adhere to the cornea, while the iris frequently attaches to its inside. In this case, the cornea becomes spongy, thick, and vascular; and, when cut, there is red blood in it;* and in staphyloma,† the iris is generally attached to the cornea. I have a preparation in which the form and character of the iris is entirely lost; it is extended into a reticulated membrane which lines the surface of the extended cornea.

OF THE CHOROID COAT.

The choroid is the vascular tunic of the eye; it is so called from its resemblance to one of the membranes of the secundines. It is the middle coat of the eye, lying betwixt the sclerotic coat and retina. Injections show it to consist of two layers of cellular tissue; and it has upon its inner surface a pigment, which, being sometimes firm, might be taken for a membrane. It was Ruysch who observed this division of the choroid coat into two laminæ; and the inner one his son called the tunica Ruyschiana: but of these hereafter.

Those anatomists who supposed the sclerotic coat to be the production of the dura mater, naturally concluded, that the choroid coat was derived from the pia mater; and as Ruysch found it to be dividable into two laminæ, so Sladius found the pia mater to consist of two membranes. It followed that the one lamina of the choroid coat was the continuation of the tunica arachnoides, and the other of the pia mater; but this account of these membranes has no support from observation.

* Pterygium, is a disease of the conjunctiva, but which resembles a membrane extended over the cornea from the canthus. Pannus, is a disease of the same kind, but covering the cornea as with a white opaque membrane.

† Staphyloma uvea, viz. a protrusion and opacity of the cornea; which, from the loss of transparency and the general appearance of the tumour, is supposed to resemble a grape.

Betwixt the pia mater and choroid coat there is no resemblance; the latter we shall find loaded with vessels: but these vessels are peculiar, and minister to a secreting surface. The pia mater in the brain, and optic nerve, is in strict union with the substance of the brain, and supports and nourishes it; but the choroid coat has no connection with the retina or expanded nerve.

There can be no better mark of distinction between membranes than their degree of vascularity, and particularly in the manner of the distribution of their vessels. The choroid coat is most particular in the distribution of its arteries and veins. The great arterial vascularity of the choroid coat is to be seen only after a very minute injection, and the venous vascularity after artificial or accidental infarction of the blood, or by a successful injection from the superior cava;* although the very great vascularity of this coat was known to our oldest writers, yet the appearance of these vessels, when empty, has deceived many. Morgagni† and Maitre-jean have described fibres which they affirm to be distinct from the vessels, but which prove to be, in fact, the appearance presented by the collapsed vessels.

The great peculiarity of the choroid coat, is its being a secreting membrane; by which I mean, that the pigmentum nigrum which is applied to the medullary lamina of the retina, being a secretion, the choroid coat has necessarily that peculiar structure of vessels which belongs to the secreting membranes. This structure has enabled anatomists to tear it into laminæ. For that part of the choroid coat next the sclerotic is merely a vehicle of vessels and nerves, and is a tissue of them connected by very fine cellular membranes. The internal part, again, is organized into a secreting surface, and is the tunica Ruyschiana.‡ I conceive, that the division into the choroid coat, and tunica Ruyschiana, is warranted from the nature of the membrane, as the divisions of the coats of the intestines are.§

Morgagni says, that from his earliest youth, he had many proofs that the choroid coat was not single in brutes; he asserts, also, that Franciscus Sylvius and Guenellonius had demonstrated the double laminæ of this membrane before Ruysch.‖ Certain it is, that Ruysch was not so fortunate in ascribing a use to this tunica Ruyschiana. He supposed that it gave strength to the choroid coat, and, by bringing a greater

* An observation of Walter.

† Morg. Epist. Anat. xvii. 2.

‡ Ruysch. Epist. Anat. xiii.

§ Albini Annot. Acad. lib. vii. cap. iv.

‖ Morgagni Epist. Anat. xvii. 3.

afflux of arterial blood, supplied the necessary heat to the otherwise cold humours.*

Tapetum.—The internal surface of the choroid coat has been long called tapetum, from its villous or fleecy appearance, when seen through the microscope. This surface in the adult is of a brown colour; in very young subjects, it is red and bloody; and, when minutely injected, it is like scarlet cloth. It is by this vascular surface or tapetum that the black pigment, which is laid under the expanded retina in the human eye, is secreted.

The pigmentum nigrum.—The pigmentum nigrum is the black or deep brown mucous substance which lies between the choroid coat and retina. It is of a nature to be washed away with a little water and a soft pencil.† This brown taint pervades the whole texture of the choroid coat. This matter is in immediate contact with the medullary pulp of the optic nerve. Its use is apparently to stifle the rays of light after they have impinged on the sensible surface of the retina; for we know that blackness is owing to the absorption of the light, as whiteness and colour is the reflection of it from the surface of bodies. The dark colour of the secreted pigment of the choroid coat is, in some measure, peculiar to those animals which see in the brightest light of day; but is wanting, or of a bright reflecting green or silvery whiteness, in such as prowl by night. The natural conclusion, therefore, is, that the pigmentum nigrum subdues the intensity of the impression, while the reflecting colours of the surface in animals which see in the night, strengthens the effect of the light on the surface of the retina, by repelling it. As fishes have the other provisions for seeing in an obscure light, they have also this of the reflecting surface of the tapetum: as it is a secretion of the villous surface of the choroid, we see why it becomes somewhat deficient in old men, and sometimes wanting in the degenerate varieties of animals; when entirely deficient, the blood circulat-

* Quod ad usum tunicæ Ruyschianæ attinet crediderim hanc tunicam inter ceteros usus esse destinatam, non solum ad robur choroidæ, verum etiam ut a sanguinis arteriosi majori copia requesitus calor tribus humoribus natura frigidis conciliaretur. Ruys. Respons. ad Christ. Wedelium, p. 14.

† I cannot conceive how this matter should be confounded with the tapetum or tapis, which, as the name implies, is the villous surface of the choroid coat. Tapetum is, properly, cloth wrought with various colours; and the analogy was first used by the French Academicians, in their account of the dissection of a lioness. "The membrane which is put into the bottom of the "eye, and laid on the choroides, which we call the tapetum, was of an Isa- "bella colour, intermixed with a greenish blue. It was easily separable from "the choroides, which remained entire, with its ordinary thickness. after that "we had taken away the membrane which forms the tapetum." The explanation of this, I suppose, will be found in Morg. Epist. An. xvii. 3.

ing in the vessels of the choroid coat gives a lurid redness to the reflections from the bottom of the eye.*

Finally, in regard to the choroid coat, we have to understand that it consists of two laminæ: the outer, and that which is next to the sclerotic coat, being the proper choroid; the internal lamina, the tunica Ruyschiana: that on the surface of the tunica Ruyschiana, there is a pile or fleece, which is called tapetum: and lastly, that the secretion of this inner surface is a pigment, which, in the human eye, has the appropriate name of pigmentum nigrum; but in many animals, it is of a silver, golden, or Isabella colour; though, in my apprehension, the colour, in all these varieties, depends still upon a peculiar secreted matter.

ANNULUS LIGAMENTOSUS.

When we take away the sclerotic coat from the choroides, we see at the termination of the choroides forward in the iris, a white ring: this should be called the ciliary ligament: it is the bond of union betwixt the choroid coat, the iris, and corona ciliaris. Soemmerring calls this the annulus gangliformis tunicæ choroidiæ.

OF THE CILIARY PROCESSES, OR CORONA CILIARIS.

The ciliary processes are formed of the anterior margin of the choroid coat; they give the appearance as if the choroid coat, at the anterior part, were folded inward to the margin of the chrystalline lens; and, as if, to accommodate it to this sudden inflection, it had been plated, and not regularly contracted; at least, this is much the appearance of the circle of ciliary processes, when, after cutting across the eye, we look from behind upon the lens in its natural situation. In this view, we find the pigmentum nigrum of the choroid coat continued over the ciliary processes, which gives to them the appearance of the regular plicæ of the choroid coat, converging to the edge of the lens, and forming altogether a disk round it.

When the black paint on the ciliary processes is a little washed away, and when we attentively examine this part, we find the ciliary processes to be actually little oblong plicæ,

* As the pigmentum nigrum is a secretion, we shall not be surprised to find it become deficient in the commencement of some diseases of the eye. This is known by the possibility of seeing to the bottom of the eye; that is, the choroid coat becomes a reflecting surface, and throws out the beams like a cat's eye. See Med. Obser. and Enquiries, vol. iii. p. 124.

which gradually arise from the choroid coat at the angle of its inflection, and terminate abruptly, approximating, but not attached to the margin of the lens. When the paint is washed entirely away, the whole circle of these processes appears evidently to be the continued choroid coat.

When not injected, the ciliary processes are pale and loose; but when minutely injected, they take a perfect scarlet colour: they resemble, in their uninjected state, the valvular-like doublings of the villous coat of the stomach and intestines. Before the choroid coat is inflected towards the lens, in the form of ciliary processes, it forms a firm adhesion to the sclerotic coat near the circular margin of the cornea, and at the same time is united firmly to the root of the iris forming the annulus ligamentosus. From this, the processes tend inward, and a little backwards; and are, at their external extremities, detached from the iris; nor are they attached to the margin of the lens, but are loose and floating.

When the vitreous humour and lens fall out from the anterior segment of the eye, we find that the plicæ or ciliary processes have left their impression on the anterior surface of the vitreous humour, and also on the intermediate expansion of the retina which extends before the membrane of the vitreous humour. This circular impression of the ciliary processes is called by Haller, striæ retinæ subjectæ ligamento ciliari.* I have called this impression HALO SIGNATUS, because it is formed of a circle of radiations, formed by the impression of the ciliary processes, and is not peculiar to the retina, but the retina again makes its impression on the membrane of the vitreous humour. The furrows and doublings of the anterior part of the retina, formed by the impression of the ciliary processes, Dr. Monro has called the ciliary processes of the retina; but, for my part, I think this a term likely to confound and mislead a student; and we might as well speak of the ciliary processes of the vitreous humour, or of the membrane of the vitreous humour, since they also take the impression of the ciliary processes.†

When the vitreous humour and lens are taken out of the coats, we see also that the ciliary processes have left the stain of the fuliginous paint.‡ This it is necessary to remark, since I have seen students confound this mark with the ciliary pro-

* Fascie vii. icon. ocul.

† Winslow uses the term sulci ciliares, for the impression on the vitreous humour. Zinn calls this corona ciliaris, after Camper: he describes them well, p. 75.

‡ See Morgagni Epist. Anat. xvii. n. 13. and Ruysch also, "Nonnuli pro processu ciliari agnoscunt pullas pigmenti nigri reliquias, membranulæ tenuissimæ humoris cristallini & vitrei, & quasi fibres mentientes, oculo sc. aperto, humoribusque exemptis; hæ autem nil sunt nisi avulsæ particulæ pigmenti nigri." Ruysch. Thes. An. ii. Ass. I. No. xv.

cesses themselves. The ciliary processes are of a most elegant vascular structure. Their contorted arteries are beautifully represented in Zinn's figure. He traces them from the extreme branches of the choroid coat; but, of their veins, he says nothing further than that they are continued from the branches of the vasa vorticosa, or veins of the choroid coat. The points of the ciliary processes are not attached to the lens, but float loose in the posterior chamber of the aqueous humour;* but at a little distance from their points they adhere to the retina, where it is continued over the anterior part of the vitreous humour. Through this attachment only are they connected with the lens; for, as we shall find presently, the retina (as a membrane, but not as the sensible retina) is continued over the chrystalline lens.†

Soemmerring [*Icones oculi humani*] describes the retina as spontaneously falling off and separating from the exterior circle of the *corona ciliaris*. But he also has mistaken the nervous matter which stops here for the whole retina. The transparent tunica vasculosa retinæ proceeds to the lens.

The ciliary processes, collectively, form a circle round the lens, which I call corona ciliaris: this circle forming a perfectly opaque partition, which stifles all rays that might otherwise be transmitted by the side of the lens. The corona ciliaris, or ciliary circle, no doubt, serves at the same time as a connection between the outer and strong coats of the eye and the transparent coats and humours; for, it is to be observed, that excepting the connection which naturally exists between the optic nerve and retina, this slender hold which the ciliary processes take of the expanded retina, is the only attachment betwixt the humours of the eye and the proper coats.

In regard to the names appropriated to this part of the eye, there is more confusion than it is possible to believe. It is necessary to attend to this ambiguous use of terms, else we shall be in danger of misunderstanding our best authors. Vesalius considers the whole as a septum betwixt the vitreous and posterior chamber of the aqueous humour; but he seems to find much difficulty in giving it an appropriate name.‡ Fallopius and Morgagni§ use the term CORPUS CILIARE for the whole circle of the processes, and in the same sense that I have

* This was demonstrated in a particular manner by Ruysch and Morgagni.

† Zinn and other later writers have entertained the idea, that the adhesion of the ciliary processes to the membranes covering the vitreous humour is by a kind of gluing, rather than a union by cellular membrane. See Zinn, p. 75.

‡ "Neque mihi ullum occurrit nomen quod ipsi aptius indam quam tunicæ: aut si voles, interstitii vel scepti inter vitreum humorem & eum quem albugíneum nuncubamus repositi." Vesal. vol. i. p. 558.

§ Epist. Anat. xvii. 11.

ventured to use corona ciliaris. It is a name which conveys the idea neither of the shape nor of the substance of the thing meant. Ruysch makes great confusion by his use of terms; the corona ciliaris, or ciliary body, he calls the ligamentum ciliara; and the lines on the back surface of the iris, he calls processus ciliaris musculosus; or rather, he means by this, the straight fibres of the iris.* Duverney, with Ruysch and Winslow, following Fallopius, calls the corona ciliaris also ligamentum ciliare. But the ciliary ligament is used by others in a widely different sense, viz. for the circular root of the ciliary body and iris, the anulum album cellulosum, or the frenula membranosa of Zinn. By Hovius, what I have called halo signatus, is called ligamentum ciliare. In Haller's fifth figure of the eye, this circular root of the ciliary processes is called orbiculus ciliaris. Maitre-jean, Haller, and others, call the whole body, or corona, the ciliary circle. M. Ferrein, Lanneau de la Choroide, and M. Lieutaud, denominated the ciliary processes "rayon ciliares," and the root of the corona ciliaris and iris, "plexus ciliaris."

CHAP. III.

OF THE IRIS.

The Iris is the coloured circle which surrounds the pupil, and which we see through the transparent cornea of the eye. It is a membrane hung before the crystalline lens.† It is as if perforated in the middle; and this hole in the middle of the iris is the pupil; and through the pupil only can the rays be transmitted to the bottom of the eye. When we hear of the dilatation and contraction of the pupil, we have to understand the action of the iris, which, by possessing the power of con-

* Ruysch has this expression: "Ligamentum ciliare neutiquam esse considerandum tanquam musculum ad pupillæ et humoris cristallini motum destinatum, totumque hoc negocium perfici a processu ciliari ut et a circulo musculari posterius in confinio pupillæ sito." Thes. Anat. ii. xv. See also the explanation of fig. iv. of this Thesaurus, where we have "Iris enim est facies exterior, processus lig. ciliaris facies interior."

† Winslow and Haller, and most of the old anatomists, call this UVEA: by which they mean to imply that it is a part of the choroides. See Ophthalmagraphia Authore G. Briggs, Cantab. 1676; but most of the modern anatomists follow Zinn and Lieutaud in calling it iris; though Lieutaud and others called the anterior surface only iris, while they still continue to call this perforated membrane choroides or uvea. See Lieut. p. 117. Again, others call the posterior surface of the iris uvea, from its likeness to the dark colour of a raisin; and the word iris is borrowed, I suppose, from the varied colours of the rainbow.

Bell del^t

Fig 1

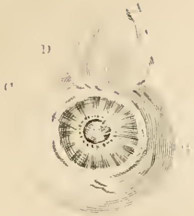
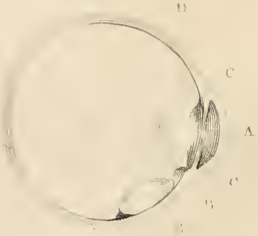


Fig 2

Fig 3.

Fig. 4.

Fig. 5



Bell del'

tracting and relaxing, holds a control over the quantity of light transmitted to the bottom of the eye. For, by the extension of this membrane, the diameter of the pupil is diminished, and, by contraction of the membrane, it is dilated. This motion of the iris, and, consequently, the size of the pupil, is connected with the sensation of the retina; by which means, in disease of internal parts of the eye, it is often an index to us of the state of the nerve, and of the possibility of giving relief by operation.

The iris, and corona ciliaris, or ciliary processes, are, in general, considered as being the two laminæ of the choroid coat, continued forward and split: the internal lamina of the choroid forming the corona ciliaris, and the outer one forming the iris. The former I was willing to consider as the anterior margin of the choroid coat, because it has no distinction in its structure from that coat; but the iris I cannot consider as the continued choroid coat; in the *first* place, because I have found it fall out a perfect circle by maceration; *secondly*, because it has no resemblance in structure to the choroid coat; and, *chiefly*, as by its power of contracting, it shows a widely different character from any of the other membranes of the eye.

The outer surface of this circular membrane gives the colour to the eye during life; and from its beautiful and variegated colours, it has gained to the whole membrane the name of iris. Haller and Zinn, nearly at the same time, explained the cause of this coloured iris, which had been, till then, supposed to be occasioned by the refraction of the light amongst its striæ and fibres.

When this membrane is put in water, and examined with the microscope, its anterior surface is seen to be covered with minute villi. The splendid colouring of the iris proceeds from the villi; but by beginning putrefaction, the splendid reflection fades, as the brilliant surface of the choroid of brutes is lost by keeping. For this reason, I imagine the colour and brilliancy of the iris to depend on the secretion of these villi. But the colour of the iris depends, in a great measure, on the black paint upon its posterior surface shining through it; and the black and hazel-coloured iris is owing to the greater degree of transparency of the iris, which allows the dark uvea to shine through it.

The iris is acknowledged to be the most acutely sensible part in the body. We have, then, to expect in its composition, muscular fibres, and to account for its acute irritability and sympathy, by a profusion of nerves: again, as the power of the muscular fibre, and the sensibility of the nerve, are both, in some measure, indebted to the circulation of the blood; we may ex-

pect to find also a profusion of vessels in the iris. In all these respects we shall find the iris to be an object of admiration.

OF THE MUSCULAR FIBRES OF THE IRIS.

It is evident, from a note under the head corona ciliaris, that Ruysch had observed two sets of muscular fibres in the iris; for, under the name of ciliary ligament, he describes a set of radiated fibres which go from the ciliary processes towards the circular margin of the pupil: he observed also, the circular or orbicular fibres which run round the margin of the pupil. Winslow says, that between the two laminæ of the uvea (viz. iris) we find two thin planes of fibres, which appear to be fleshy: the fibres of one plane orbicular, and lying round the circumference of the pupil, and those of the other being radiated; one extremity of it being fixed to the orbicular plane, the other to the great edge of the uvea. Zinn describes, with much minuteness, radiated fibres, (on the anterior surface of the iris,) but does not consider these as muscular fibres; and he confesses, that he could not observe the orbicular muscles which Maitre-jean and Ruysch had painted. Even in owls and other creatures having a strong iris, he could not discover an orbicular muscle; nor were Haller and Morgagni more successful in this investigation.* Wrisberg also affirms, that no muscular fibres could be seen in the iris of the ox. Dr. Monro, on the other hand, adheres to the opinion of the muscularity of the iris; he describes minutely both the radiated and sphincter fibres. Wrisberg and others have thought they found sufficient proof against the muscularity of the iris, in the fact of its not contracting when the light falls upon its surface. To this Dr. Monro answers, that the colour or paint upon the iris must, like a cuticle, prevent the light from irritating the iris. I cannot think that this circumstance should prevent the excitement of the iris. The retina is in a peculiar manner susceptible of the impression of light; but we cannot wonder that light should not stimulate a muscle to contraction, when we have every proof that it has no effect on the most delicate expanded nerve of the other senses.

That the iris is to be affected only through the sensation of the retina, or perhaps rather the effect communicated to the sensorium, we have sufficient proof. I have, in couching, repeatedly rubbed the side of the needle against the iris without exciting any motion in it: I have seen it pricked slightly by

* See Zinn, p. 89 and 90. Morgagni Epist. Anat. xvii. § 4. Haller and Ferrein attribute the motion of the iris to an afflux of humours in its vessels.

the needle without its showing any sign of being irritated; nay, what was too convincing a proof, I have seen it cut by falling before the knife in extracting the cataract. In this last instance, far from being stimulated to contraction, it hung relaxed.*

It is evident, then, that no common stimulus, immediately applied to the iris, has any sensible effect in exciting it to contraction; and that it is subject only, in a secondary way, to the degree of intensity of light admitted to the retina. The movement of the iris is in general involuntary; but terror and sudden fright affect it. In some animals, particularly in the parrot, it is a voluntary muscle.† As an object, upon which we look, approaches the eye, the pupil contracts, which is an effect of the increasing intensity of the light reflected from the object; for, as the object advances, it fills a greater space in the sphere of vision, and of course more rays flow from it into the eye.

Nerves of the iris.—The iris is supplied with nerves in great profusion. They are derived from the long ciliary nerves which run forward betwixt the cornea and choroid coat towards the common root of the corona ciliaris and the iris. They there divide, and are seen to pass in numerous branches into the substance of the iris. In the substance of the iris, the branches of the nerves, from their extreme minuteness, are soon lost amongst its pale fibres.

Blood-vessels of the iris.—I have had preparations which showed so great a degree of vascularity in the iris, that I was ready to believe its action to be produced entirely by a vascular structure; but when, on other occasions, my admiration was excited by the profusion of nerves, and I was led to observe that in the former instances they had been obscured by the injection, I could not but allow that the muscular fibres might have been obscured as the nerves were.

There are four arteries sent to the iris: two long ciliary arteries which take a long course on the outside of the choroid coat, and two lesser and anterior arteries which pierce the ligamentum ciliare from without. These arteries approach the

* This fact destroys the hypothesis of M. Mery, of the Royal Acad of Sciences, that the straight fibres of the iris are little cavernous bodies, and that the action of the light upon the retina swelled and elongated them so as to cause the diminution of the size of the pupil; for by this cut, they must have fallen from their erected state, and contracted so as to have dilated the pupil. See Acad. Roy. des Sc. 1704, Mem. p. 261.

† When a cat is roused to attention, as by the scratching of a mouse, it dilates the pupil, which allows a stronger impression on the bottom of the eye: nay, whenever puss struggles violently to get loose, the pupil dilates, which may sufficiently account for M. Mery's cat having her pupil dilated when he plunged her under the water. See Acad. Roy. des Sc. 1704, Mem p. 261.

root of the iris at four opposite points, and branching widely form a vascular circle round the root of the iris, viz. the larger circle of the iris. From this circle branches pass off, which run with a serpentine course, converging to the edge of the iris: here they again throw out inosculating branches, which form a circle surrounding the pupil, but at some little distance from the edge of the iris—this is the lesser circle of the iris. From this lesser circle there again proceed minute branches towards the edge of the iris.*

The VEINS, which intermingle their branches with these arteries, pass some of them into the vasa vorticosa of the choroid coat, and others take a long course betwixt the choroid and sclerotic coat, accompanying the ciliary nerves, whilst some branches pierce the sclerotic coat at the root of the iris, and become superficial upon the fore part of the eye.

IT was at one time believed, on the authority of many excellent anatomists, that the vessels of the iris were colourless, and did not circulate red blood: after what has been said, it is scarcely necessary to mention the fallacy of this opinion.† I have seen the iris cut and bleeding, though not profusely as I expected ; the small quantity of blood soon coagulated into a dark speck, while I expected it should have been effused in the aqueous humour.

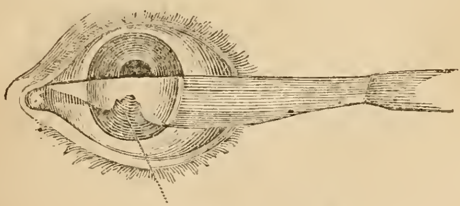
There is a circumstance in the operation of extracting the cataract which I have seen little attended to, and yet it is sufficiently evident. When the cornea has been cut, operators, disappointed in not finding the cataract protruded, keep the eye staring in the light, and press the ball of the eye ; but while the eye is thus exposed to the excitement of the light, the pupil is contracted, and the lens propelled by the action of the muscles ; and, still more, by the pressure made on the eyeball, is in danger of pressing through and tearing the iris. The best operators have been in the custom of shutting the eyelids the instant the incision is made in the cornea ; by this means, the eye is for a time supported in some degree during the violent spasm of the recti muscles, and the iris being allowed to dilate, the lens is protruded into the anterior chamber of the aqueous humour through the pupil, and is ready to slip from under the cut cornea, when the eye-lids are again opened. By this means, if the incision of the cornea is of the proper extent, the lens is not *extracted*, but is *protruded*, by the action of the muscles of the eye.

* See Ruysch. Epist. Anat. Prob. xiii. p. 31.

† Dr. Monro, in treating of this subject, mentions his having seen a network of vessels covered with paint darker than that of the iris, and extended from the iris upon the surface of the lens; and, in another instance, a network of filaments passing quite across the pupil. See his Dissertations, p. 108.

It is very necessary for us to remember, that all the parts of the eye, in themselves extremely delicate, are kept in their relative places, not by adhesions, but by the complete support they derive from the globular form of the eye, and by the strength of the outer coat or sclerotic and cornea. To this, it is particularly necessary to attend, in the operation of the extraction of the cataract; for, as soon as the aqueous humour is evacuated, the uniform resistance of the coats of the eye is destroyed, and the muscles surrounding the eye-ball force all the humours towards the incision. It is this circumstance which brings the iris into great danger of being cut when the knife is too narrow to make the incision at once, by pushing it through the cornea with an uninterrupted motion of the fingers. For, when the knife is not broad enough to cut itself out by moving it uniformly along, the aqueous humour escapes in the endeavour to cut downwards, and the iris is protruded so as to fall under the edge of the knife; nay, with a good knife, and of a shape to cut itself out, and at the same time adapted to make a cut in the cornea sufficient to allow the escape of the lens, I have seen, in consequence of a hesitating manner of introducing the knife, the aqueous humour suffered to escape. Now, observe the consequence of this:—The lens being pushed outwards by the contraction of the muscles on the eye ball, towards that point at which the continuity and consequent uniform resistance of the coats were broken, the margin of the iris was forced under the edge of the knife and cut, as I have here represented.

Fig. 2.



The margin of iris fallen before the edge of the knife and cut.

A very particular effect of this cut upon the margin of the iris is to be observed.—When the incision has been happily done, the lens is protruded uniformly through the pupil; but when the iris was cut, as now explained, the edge of the lens opposite to the part of the iris which was cut, was forced forward; the lens was turned side-ways, without being entirely displaced; and a great part of the vitreous humour was allowed to escape.*

* See further, Operative Surgery, by C. Bell.

CHAP. IV.

OF THE RETINA, AND DIGRESSION CONCERNING THE SEAT OF VISION.

The term retina has, in a modern publication, been objected to, as improperly applied to the inner coat of the eye. Such a term, it has been said, may well be applied to the nerve expanded on the lamina spiralis of the cochlea, because it is there formed into an intricate plexus by innumerable joinings and separations of its component parts; but used for the expanded nerve of the eye, the term retina is thought improper.* We must look for the resemblance, however, which justifies this term, not in the medullary matter of the nerve, but in its vessels. "Hanc figuram egregie repræsentat dicta tunica retina cum arteriolæ ceracea materia sunt repletæ."†

The retina is the expansion of the optic nerve; the immediate seat of sensation, and the most internal of those membranes which are called the coats of the eye. It has been already observed, that there is a distinction betwixt a nerve in its course from the brain to the organ of sense, and where it is actually expanded and adapted to the reception of the external impression. Before the optic nerve has perforated the sclerotic coat of the eye, it is surrounded with a firm sheath; and its substance is evidently composed of bundles of fibres, though not so coarse, yet like those of the nerves in the other parts of the body. The opacity of the nerve makes it have little the appearance of vascularity, but when the body of the nerve is made transparent, it becomes like a red cord; so necessary is it that the medullary substance of the nerve be supplied with blood.

The stronger sheath which surrounds the body of the optic nerve is loose, and may be separated into lamellæ. There is a more delicate membrane which immediately adheres to the surface of the nerve; and its substance is formed into the minute fasciculi which give it the fibrous appearance by a still firmer intertexture of membrane. This interwoven membrane proceeds, with the retina, into the eye; the other sheaths are reflected off, and unite with the sclerotic coat. Some little way from the back part of the eye, the arteria centralis retinæ pierces the sheath of the nerve, plunges into the centre, and passes into the eye along with it. If the optic nerve be cut near to the eye, the open mouth of this small artery may be seen; but if we make our section some way removed from the

* Dr. Monro's 4to. Treatises.

† Ruysch. Epist. Anat. xiii. p. 14. Quamobrem servare adhuc retinæ, appellationem si non ex fibrarum ut certe ex vasorum implicatione, &c. Morgagni Epist. Anat. xvii. § 43.

back of the eye, it will, of course, not be seen. The space left by the artery contracting in the centre of the nerve when thus cut, (or perhaps it was the open mouth of the artery itself,) was observed by the ancients, and by them called the porus opticus; they were ignorant of this central artery of the retina.*

Where the optic nerve is about to enter into the ball of the eye, it is much diminished in diameter; it is contracted and condensed, and, at the same time, lays aside the strong coats. The proper nerve then perforates a cribriform lamina in the sclerotic coat. Within the eye, the filaments seen in the nerve are no longer distinguishable; but from the extremity of the nerve the fine web of the retina is produced.

The LAMINA CRIBROSA, and the delicate fasciculi of the optic nerve, are shown in this manner: after making a section of the eye, wash away the retina from the extremity of the optic nerve, and also the choroid coat; then press the optic nerve betwixt the finger and thumb, when the pulp of the nerve will be seen to protrude through the foramina in the sclerotic coat like white points. It is observed by Zinn, that, in doing this, there is a central foramen which remains unfilled up by the compression of the nerve. This is the hole perforated by the arteria centralis retinæ.† Where the threads of nerves are accumulated after passing these foramina, and before they are finally expanded into the retina, they necessarily form a small cone or papilla. This conical form of the extremity of the optic nerve is much more evident in some animals than in others; but in a section of the human optic nerve we may also observe it.‡

The retina is a membrane of the most delicate texture of any in the animal body: it is transparent in the recent state, and so soft, that it will tear with its own weight. In spirits and weak acids, it becomes opaque and firmer. It lies expanded over the vitreous humour, and contiguous, but not adhering to the choroid coat, or its pigment. The retina does not consist merely of the expanded nervous matter, but has in its composition a very fine membrane, and many minute vessels. When the retina is macerated for a considerable time, the pulp of the nerve can be washed away, and there remains only the reticulated and delicate membrane which supports the vessels

* Porum opticum Herophilus et omnis ab ea antiquitas dixit, foramen nempe quod in dissecto nervo de vacua arteria superest. Hall. Arter. Ocul. Hist. p. 42. De Vasis Nervi Optici vide Ruysch. Epist. Anat. xiii. tab. xvi. Albinus Acad. Anat. lib. vii. c. vii.

† Zinn de oculo humano p. 106. Com. Reg. Soc. Scient. Gotting. loc. cit. About 30 foramina have been observed in the lamina cribrosa. See Haller Fasc. de Arter. Oculi, p. 42.

‡ Zinn. "At the place which answers to the insertion of the optic nerve, we observe a small depression, in which lies a sort of medullary button terminating in a point." Winslow, p. 78.

that nourish it. But though the pulp of the nerve may be dissolved, it cannot, by dissection, be freed from the membrane which supports it.*

I have a preparation which more resembles some of Ruysch's plates than any I have seen. In this preparation, the nerve being washed away, we may see distinctly the whole course of the arteria centralis retinæ. Of this preparation I have given an engraving, to show how plentifully this organ is supplied with red blood; from which circumstance we may learn the strict dependence of its function on the circulation, and deduce the derangement of the powers of vision, as a natural consequence of the disordered action of these vessels.

The soft medullary matter of the retina is towards the surface of the choroid coat, and forms there a lamina, which appears to me to be the surface of the nerve upon which the rays of light impinge.† The vessels of the retina run upon the surface contiguous to the vitreous humour.‡ The arteria centralis retinæ is derived from the ophthalmic artery. It pierces the optic nerve, as we have already observed, and enters the eye through the porus opticus, to supply the retina. But the arteries of the retina do not always enter into the eye in one trunk; on the contrary, sometimes two or three branches pierce the lamina cribrosa,§ and afterwards, two, three, or four principal branches, spread out on the circumference of the retina; from these, the ramifications are so numerous, that Ruysch describes them as constituting the membrane.‖ Cor-

* Posse vere Medullarem retinæ laminam removeri ut vasculosum rete membranæ figuram retineat, alteramque ab altera integram detrahi ultra hominum artem positum esse videtur nec ulli unquam contigisse legere me memini, etsi, deleta macerendo medulla, rete vasculosum laminam peculiarem referre videatur. Ex quibus omnibus elicio retinam esse tunicam simplicem, ex cellulosa conflatam: que vascula et substantiam medullarem sustinet etsi duas diversas ostendat facies alteram vasculosam interiorem, alteram medullarem exteriorem." Zinn, p. 112.

† "C'est sur-tout dans les poissons qu'il est facile de distinguer et meme de separer ces deux lames." Cuvier, tom. ii. p. 419.

The opacity of the outer surface of the retina prevents the vascularity from being apparent Albinus, after a very minute injection, observed that when he lifted up the choroid coat, the vascularity of the retina was not seen: "Autem de ea aliquid acuto scalpello subtiliter levissimeque deradens, mox conspicia vasa impleta multa quæ sub medulla cujus nimirum portionem deraseram latuerant." Albin. An. Acad. lib. iii. cap. xiv.

‡ Dr Monro has these words, expressive of an opposite opinion: "The whole appears to be composed of an uniform pulpy matter, on the outer side of which chiefly vessels are dispersed, supported, I suppose, by a membrane the same or analogous to the pia mater." 4to. Treatises on the eye, ear, &c.

§ Haller loc. cit. Morgagni. Ep. Anat. xvi. n. 44. nor do they always pierce the centre of the nerve exactly. Morgagni.

‖ "Iteratis perscrutiniis reperio oculis armatis arteriolarum extrema tam esse numerosa & tam arcte sibi invicem et intricate annexa ut peculiarem representent membranulam ex arteriolarum extremis constitutam, cui connectetur dicta medullosa substantia." Ruysch. Epist. Anat. xiii. p. 15.

responding with the arteria centralis retinæ in the adult, there are veins, the minute extremities of which, after forming connections with the veins of the corona ciliaris, run backwards on the inner surface of the retina in three or four distinct branches. These uniting into a trunk, perforate the lamina cribrosa, and become the socia arteriæ centralis.

Many have been led to believe, that the retina terminates forward on the roots of the ciliary processes, as others have conceived it to be continued over the forepart of the vitreous humour, and over the surface of the lens;* but the most prevalent opinion is, that it terminates on the margin of the lens.

That the retina extends over the back of the lens, and receives there the impression of light, is very improbable; but that the membrane which supports the retina, is continued over the lens, is demonstrable. As I have just said, the retina I conceive (with Albinus, M. Ferrein, and others) to consist of two distinct parts, viz. the medulla of the nerve, and the pellucid membrane supporting it; but, however reasonable this conclusion is, I cannot believe that these portions are to be separated by dissection. It is, by most anatomists, believed, that the retina passes forward between the vitreous humour and ciliary body, and adheres to the margin of the lens. Now, as this adhesion is not a gluing together of parts, but a union or intermixture of membranous filaments, the interchange and mingling of fibres, we may safely say, that the membrane of the retina is continued over the lens, and forms part of its capsule. The opacity of the retina is diminished at the root of the ciliary processes, and disappears altogether at the margin of the lens; and here it is not only changed by becoming perfectly transparent and allied to the membranes of the humours, but it becomes also distinguishable from the opaque retina by a greater toughness and strength. The continuity of the retina with the capsule of the lens is more apparent, when both membranes have become opaque by being immersed in spirits or vinegar, but more particularly when that opacity is produced by disease. In disease, I have found the veins of the retina running over the margin of the lens, and branching on its posterior convexity.

Where the retina lies betwixt the vitreous humour and the ciliary processes, it is plaited, and descends into the interstices of these processes.

When we take off the sclerotic and choroid coats of the eye, by dissecting them round the insertion of the optic nerve, and

* Many anatomists, Winslow, Cassobohm, Ferrein, Lieutaud and Haller, have taught that the retina extends over the great convexity of the lens, or that it is inserted into it. Galen believed it to extend over the lens. For an impartial history of opinions, see Morgagni Epist. Anat. xvii. 47. and Zinn, 114.

fold them back, carefully preserving the retina; and when we have taken away the ciliary processes from their adhesion to the forepart of the retina, we find the retina to form a sac surrounding the vitreous humour, and supporting the lens. In all this surface, the membrane is smooth and uninterrupted. To the margin of the lens all this sac is opaque; because upon the outside of the retina, is the opaque pulpy nervous matter, but the coats of the lens are transparent, yet continuous with the arachnoid portion of the retina. When these parts of the eye are thus dissected, they hang altogether by the optic nerve; viz. the lens, the vitreous humour, and the expanded matter of the nerve being supported by delicate and pellucid membranes, constituting part of the retina; and the organ is divested only of its outer apparatus; we still retain within this the more essential and important parts.

THERE is here a natural division; and I am willing to pause upon this, knowing well with how much difficulty the student gains a knowledge of the minute structure of the eye. All within the connections of the retina I shall call the INTERNAL GLOBE of the eye, as distinguishing it from the outward coats of the eye and parts subservient to them. A view of the little vascular system of these internal parts, thus classed, will show how strictly they are connected together, and how much insulated from the other parts.

But this is a subject upon which we cannot venture until we have considered the nature and relative situation of the humours of the eye.

DIGRESSION ON THE SEAT OF VISION.

M. L'Abbé Mariotte discovered the curious fact, that when the rays fall upon the centre of the optic nerve, they give no sensation. He describes his experiment in this manner:—"Having often observed, in dissections of men as well as of brutes, that the optic nerve does never answer just to the middle of the bottom of the eye; that is, to the place where the picture of the object we look directly upon is made; and that, in man, it is somewhat higher, and on the side towards the nose; to make, therefore, the rays of an object to fall upon the optic nerve of my eye, and to find the consequence thereof, I made this experiment. I fastened on an obscure wall, about the height of my eye, a small round paper, to serve me for a fixed point of vision; I fastened such another on the side thereof towards my right hand, at the distance of about two feet, but somewhat lower than the first, to the end that I might strike the optic nerve of my right eye while I kept my left

shut. Then I placed myself over against the first paper, and drew back by little and little, keeping my right eye fixed and very steady upon the same, and being about ten feet distant, the second paper totally disappeared."*

This defect in the vision of the one eye is corrected by that of the other; for the insertion of the optic nerves being towards the side next the nose, no part of an image can ever fall on the optic nerve of both eyes at once; the defect of vision, therefore, is observed only in very careful experiments. Experiments were, however, made by M. Picard, Marriotte, and Le Cat, to render this effect produced by the image falling on the centre of the optic nerve evident, when looking with both eyes. Marriotte's second experiment was this: Place two round pieces of paper at the height of your eyes, three feet from one another, then place yourself opposite to them at the distance of 12 or 13 feet, and hold your thumb before your eyes at the distance of about eight inches, so that it may conceal from the right eye the paper that is to the left hand, and from the left eye the paper to the right hand. If now, you look at your thumb steadily with both eyes, you will lose sight of both the papers.† The novelty of such a discovery was likely, as frequently is the case, to carry men's minds beyond the true point. It requires time for such facts to descend to their level, in the scale of importance, with other less novel observations. Marriotte, upon this fact, formed a new hypothesis relating to the seat of vision. We have observed, that the choroid coat and pigmentum nigrum are deficient, where the optic nerve enters the eye, and is about to expand into the retina. He fixed upon the most unaccountable supposition, that the retina does not receive the impression of the rays, but that the choroid coat is the seat of the sense. In support of this theory, he soon found other arguments than those arising from the deficiency of the choroid coat at the entrance of the nerve. He saw that the pupil dilated in the shade, and contracted in a more intense light; now, says he, as the iris is a continuation of the choroid coat, this is a proof of the great sensibility of that coat: again, the dark colour of the choroid coat he supposed to be well calculated for the action of the rays of light, which are not reflected from it or transmitted, but absorbed; while, on the other hand, the retina is transparent. If vision were performed in the retina, says Marriotte,

* Vide Phil. Trans. No. 35. Smith's Optics. Remarks on art. 87.

† Dr. Smith made the stream of light through the key-hole of a dark chamber fall upon this point of the retina, opposite to the termination of the optic nerve, but he found it quite insensible even to this degree of light. M. Picquet asserts, that very luminous objects make a faint impression on the centre of the optic nerve. But Dr. Priestley says, that a candle makes no impression on that part of his eye.

it seems that it should be found where ever the retina is ; and since the retina covers the whole nerve as well as the rest of the bottom of the eye, there appears no reason why there should be no vision in the place of the optic nerve. M. Picquet argued in opposition to Marriotte. He observed, in regard to the fitness of the black colour of the choroides for the action of the rays of light, that the choroid is not universally black ; that there are many shades of difference in the human eye ; and that it is black, blue, green, yellow, or of a metallic shining surface, in a variety of animals. He conceived that the defect of vision at the insertion of the nerve is occasioned by the blood-vessels of the retina.* He observed, also, that the opacity of the retina is such, as necessarily to obstruct the transmission of the rays of light to the choroid coat. M. de la Hire took part in this controversy. He considered the retina as the organ of sight, although a particular point of it is not susceptible of immediate impressions from outward objects ; for, says he, we must not conceive sensation to be conveyed by any other means than by the nerves. But, observing the constitution of the other organ of the senses, he entertained an idea that the retina receives the impression in a secondary way, and through the choroides, as an intermediate organ ; that, by the light striking the choroid coat, it is agitated, and communicates the motion to the retina ; and we find that through all the organs of the senses, he continues, the nerves are too delicate to be immediately exposed to the naked impressions of external bodies.

Another objection to the opinion, that the retina is the seat of sensation, has been lately urged, viz. that the thickness of this coat, together with its transparency, allows of no particular surface for covering the image; and that its transparency would cause a partial dispersion, which would produce a confusion in vision.†

If these opinions require serious refutation, we have it in the effects of the diseases of the retina, optic nerve, and brain. But the thalami nervorum, the optic nerve, and its expansion into the retina, seem scarcely to have ever occurred to these speculators, as worthy of notice in this investigation.

The following appears to me the true account of this matter. It is demonstrated that the inner surface of the retina is a web

* Against this hypothesis, the size of the insensible spot was urged by Marriotte. Bernouilli calculated that this spot is a circle, the diameter of which is a seventh part of the diameter of the eye, and that the centre is 27 parts of its diameter from the point opposite to the pupil and a little above the middle.

† M. Le Cat thought the pia mater was the sentient part of the nerve. It was, therefore, a kind of confirmation of his opinion to suppose the choroid to be the seat of vision, as he teaches that the choroid coat is a production of the pia mater. He conceived that the retina moderated the impression of light upon the choroid coat, as the cuticle dulls the impression on the papillæ of the tongue.

of membrane conveying vessels, and that the outer surface of the retina consists of the pulpy-like nervous matter. This latter, then, is the organized surface adapted to receive the impression of the rays of light. At the point where the optic nerve comes through the coats of the eye, there is no posterior surface peculiarly adapted to receive the impression of light; and as well might we expect the optic nerve to be sensible to the impression of light in any point of its extent from the brain to the eye, as at this; for here the inner surface of the retina only is formed; there is no posterior surface upon which the rays can impinge. The doubts regarding the cause of this spot giving no sensation, have arisen from the idea, that the internal surface of the retina, or its substance, felt the impression of the rays of light.

At the same time, it is evident, that the choroid coat, and its secretion is in a most remarkable manner subservient to the retina, as the instrument of vision; for, when the secretion is black it absorbs the rays; and animals which have such a pigmentum nigrum, see best during the full day: again, when the surface is of a shining nature, it repels the rays, and this contributes to strengthen the sensation; and such animals are fitted for seeing in obscure light: nay, further, if the surface of the choroid be coloured, the animal will see objects of that colour the best, because the colour of the choroid depends upon its reflecting more of the coloured ray, than of the others of which light is composed.

But as animals see which have no paint on the choroid, neither such as will absorb, nor such as will strongly reflect the rays, and which have merely the surface of the choroid with its coloured blood-vessels in contact with the retina; so, it is evident, that it is not the deficiency of the choroid coat, nor the want of the black paint at the entrance of the optic nerve, which prevents the sensation, but really, that there is here no surface formed and organized to receive the impression of the light; the internal surface not being the sensible surface of the retina.

FURTHER OBSERVATIONS ON THE RETINA.

It has already been observed, that vision is the combined operation of the external organ, nerve, and brain; consequently, the destruction of the function may be produced by disease of the retina, of the optic nerve, or of the brain. Any partial injury, pressure, electricity, or galvanism, influencing the retina, will cause the sensation of light or fire before the eye.* Because here, or in its corresponding part of

* Light from pressure on the eye. See Cartesius, cap. ix. lib. de Meteor, and the opthalmo-graphia of Briggs, *cornea*.

the brain, is the organ of vision: and no idea but of light is this organ capable of exciting in the mind. Disease in the retina, nerve, or corresponding part of the brain, causing total blindness, while the cornea and humours of the eye remain pellucid, is called AMAUROSIS. It is, in general, to be considered as a paralytic affection. Amaurosis* has been found to follow strokes on the head; concussion and compression of the brain; blood effused within the skull; or tumours pressing on the nerve or brain.† An amaurosis spasmodica has been enumerated by authors. This kind of blindness has been supposed to arise in consequence of the stricture of the optic nerve by the origins of the recti muscles; as far as I have observed, no action of these muscles can affect the optic nerve before it perforates the coats of the eye. If it were to be attributed to the operation of these muscles, I should rather suppose it to be occasioned by their spasmodic action on the ball of the eye, by which the function of the retina may be disordered; but I think it is more probable that the same irritation which is acting on the motatory nerves of the eye, does, in this instance, affect also the optic nerve and retina. However, distention of the coats of the eye, by increased secretion of the humours, destroys the sensibility of the retina. In the hydrophthalmia there is in the beginning a short-sightedness, so that objects are seen only when near the eye. Thus far we might account for the defect of vision by the alteration of the focus of the cornea and humours; but by and bye, as the eye enlarges, as it becomes turgid, and the coats more distended, the pupil becomes stationary, and the vision is lost before the aqueous humour has become turbid.‡

The connection and sympathy betwixt the retina and the viscera of the abdomen is very particular; I have seen a proof

* AMAUROSIS; GUTTA SERENA; CATARACTA NIGRA; which last name is from the blackness of the pupil in consequence of the transparency of the lens.

† "Ipse vidi bis in puerulis scrophulosis amaurosin, etiam subito ingruentum; secto cadavere inveni glandulam strumosam nervis optisis incumbentem." *Sauvages Nosol.* From many observations, we find that tumours and extravasations, which must compress gradually, do yet produce an instantaneous effect.

In Bonetus,* we have many cases of blindness from abscess in the anterior part of the brain; from fluid on the surface, and in the ventricles; from steatomatous tumours; from coagulum of blood, and from a hydatid pressing on the union of the optic nerves, and, lastly, from a calculus in the optic nerve. Blindness from pressure upon the eye and its displacement and consequent elongation of the optic nerve, by an encysted tumour in the orbit, with gradual recovery after operations. See Med. Ob. and Inquir. vol. iv. p. 371.

‡ To complete such a case, we may further observe, that there is now an accession of pain, a tension over the forehead and pericrania, and there is sometimes accompanying it a swelling and insensibility of the side of the face. So luxation or displacement of the eye, by tumours, causes blindness, by extending the optic nerve or compressing the eyeball, and consequently the retina.

* De Ocul. Affectibus, Ob. 2.

of this in the disorder of the stomach having an immediate effect on the sensibility of the retina. Allied to this, but greater in degree, is the amaurosis which attacks hysterical women suddenly, with headach and violent pain. From such sympathy of parts arise the amaurosis bilosa, verminosa, intermittens, arthritica, &c. Such attacks of blindness have been found to alternate with convulsions.*

Commencing cataracts and opacities of the cornea, and of the humours in general, give occasion to spots and obscurities in the vision; but we have at present to consider those only which depend on the state of the nerve. Errors of vision are not easily to be distinguished from those of the imagination proceeding from the brain. Error opticus, or hallucinatio, from delirium: one distinction of the former is, that we can correct the deception by the assistance of the other senses, while, in the latter, the mind is diseased.

Old people are often troubled with the appearance of dark irregular spots flying before the eyes. In fever, also, it is very common to see the patient picking the bed-clothes, or catching at the empty air. This proceeds from an appearance of motes or flies passing before the eyes, and is occasioned by an affection of the retina, producing in it a sensation similar to that produced by the impression of images; and what is deficient in the sensation, the imagination supplies; for, although the resemblance betwixt those diseased affections of the retina and the idea conveyed to the brain may be very remote, yet, by that slight resemblance, the idea, usually associated with the sensation, will be excited in the mind.

M. de la Hire attributed the fixed spots to drops of extravasated blood on the retina, and the flying ones, to motes in the aqueous humours;† but we shall show presently, that this apparent motion of the motes before the eyes may be a deception. After turning round upon the heel for some time, objects apparently continue in motion. Dr. Porterfield supposed this to proceed from a mistake with respect to the eye, which, though it be at rest, we conceive to move the contrary way to

* The following is an ingenious account of the manner in which this may be produced, though to me it is not satisfactory:—" Non infrequens cæcitas post convulsiones graves et frequentes, sed a nemine quod sciam recte descripta causa; hanc non ab humoris affluxu deduco, ut voluerunt, sed quia in magnis illis per paroxysmas convulsionum partium omnium, et oculorum simul contorsionibus in quibus sæpe quoque convulsi, admodumque exerti et inflexi apparent, attracto sic nimium et tenso nervo optico, illis adnato illoque simul contorto et læso, spiritusque visorii transitu impedito, oculos visione privari contingit, atque inde provenire diligente examine & consideratione invenimus." Platerus, Prax. lib. i. c. 7.

† " Guttula cruoris retinæ insidens et nigricans, omnem lucem intercipiet unde phantasma obscurum vel nigrum; verum si dilutus cruor radios rubros transmittat tunc maculam rubram videbit æger ut omnia trans vitrum inspecta rubra sunt." Sauvage, vol. iv. p. 287.

that in which it moved before; from which mistake, with respect to the motion of the eye, the objects at rest will appear to move the same way the objects are imagined to move, and, consequently, will seem to continue their motion for some time after the eye is at rest. How superior is simple experiment to the most ingenious speculation! Dr. Porterfield is presuming in all this, that the eye is at rest when the body is stationary, after turning round rapidly on one foot. But the fact is, that the eyes continue in motion after the body is at rest, but owing to a disorder in the system of sensation we are not sensible of it. Dr. Wells, in making an experiment, in which it was necessary to look upon a luminous body, was seized with giddiness, and he found, that the spot on the retina, affected by the great excitement of the luminous body, did not remain stationary, but, when made apparent by looking upon the wall of any plane, was moved in a manner altogether different from what he conceived to be the direction of his eyes. In making the experiment after looking some time at a candle, and then turning himself round till he became giddy, he afterwards directed his eyes to the middle of a sheet of paper, he saw the dark spot (caused by the former brilliancy of the candle on the retina) take a course over the paper, although he conceived that the position of his eyes remained stationary. He then directed a person to repeat this experiment, and then bade him look stedfastly to him, and keep his eyes fixed; but instead of keeping stationary, his eyes were seen to move in their socket; though, of this the person himself was quite insensible.

From these experiments, we may conclude, that spots which seem to move before the eyes are not, on that account, solely to be attributed to opacity of the humours or cornea, since the appearance of motion may be given to those motes, though occasioned by an affection of the nerve; especially, if the unusual sensation be attended with giddiness. Giddiness, however, is not necessary to such sensation; when my eyes are fatigued, and, sitting in my room, I look towards the window, I see before me small lucid circles, which seem to descend in quick succession; upon attending more particularly to my eyes, I find them in perpetual motion; my eye is turned gradually downward, which gives to the spectrum the appearance of descending; but it regains its former elevation with a quick and imperceptible motion. During the slow inclination of the eye downward, the motes or little rings seem to descend; but in lifting the eye again, the motion is so quick, that they are not perceived.*

* The following quotation refers to this sensation:—" Æger in magna luce constitutus, ut plurimum presbyta, vel oculis nitidissimis gaudens continuo præ oculos observari sibi putat puncta lucida, quæ non huc et illuc volitant,

There is a kind of umbræ seen before the eyes which are occasioned by the vessels of the retina. Of this kind is the suffusio reticularis of Sauvages, in which the person sees umbrageous ramifications which strike across the sphere of vision, and are synchronous with the pulse, showing its dependence on the full and throbbing pulsation of the head. There are also corruscations seen before the eyes, in consequence of a blow upon the eyeball, and accompanying violent headach, vertigo, phrenitis, epilepsy, &c. Whatever forces the blood with great violence to the head, as coughing, vomiting, sneezing, will cause, for the instant, such corruscations, by means of the disturbed circulation through the retina.

We are particularly called upon to attend to the connection betwixt the iris and the retina. In amaurosis, the sensibility of the retina being entirely lost, the pupil is consequently immoveable and dilated.* But we must recollect, that if one eye be sound, the pupil of the diseased eye follows, in some degree, the movement of the iris of the sound eye. If one eye be shut, the pupil of the other eye will dilate; if the hand be put over the eyelids of the shut eye, the pupil will still further dilate.†

We find several instances of vision indistinct during full daylight, and perfect in the crepusculum. This we have explained by the dilatation of the pupil allowing the rays of light to pass the partial opacity of the lens; it, of course, has no connection with the disease of the retina.

There are also instances of vision being more than naturally obscure in the twilight, which is owing to a degree of insensi-

nec a commoto capite agitantur, ut putat la Hire et ejas in hoc exscriptor Boerhaave; sed constanter si oculos immobilis remaneat, deorsum lentissime delabi videntur; adeoque veluti pluvia aurea præ oculos eaque densa cernitur; quæ verticaliter semper descendit in quacunque capitis positura, sive erecta, sive lateraliter inclinata; hoc in me ipso expertus per annos, observavi in aliis, potissimum illos qui studio nocturno indulserant, et in aegrotante, qui de eo symptomate ad melancholiam fere per multos unnos solicitus erat." Sauvage. This appearance has been attempted to be explained upon the supposition of a very sensible state of the retina, which perceives the gutulæ exuding from the pores of the cornea, and which, falling over its surface, gives the appearance of their descending. But it is only felt when the retina is exhausted or disturbed by pressure on the eyeball. See Sauvages Suffusio Scintillans & Suff. Danaes.

* There are, however, cases of Amaurosis a myosi, in which there is a contracted and immoveable pupil, and children are born with an insensibility of the organ in which the pupil is not greatly dilated. I would be willing to attribute this peculiarity of the pupil and apparent amaurosis in newly born children to the remains of the membrana pupillaris.

† The sympathy of the iris with the retina I do not conceive to be immediate, but through the intervention of the brain; and the degree of dilatation of the pupil, I should hold to depend on the strength of the common sensation of both eyes. By this only can we account for the sensibility of the retina of one eye affecting the iris of the other, or the disturbance of the brain, in comatose diseases, destroying the sympathetic connection betwixt the retina and pupil.

bility.* The night blindness, however, is not to be entirely attributed to a degree of continued insensibility in the nerve. The attacks are irregular, and allied to the intermitting amaurosis. It has been epidemic, and the following cases seem to ally it with the paralytic affections.†

A man, about 30 years old, had, in the spring, a tertian fever, for which he took too small a quantity of bark, so that the returns of it were weakened, without being entirely removed; he therefore went into the cold bath, and after bathing twice, he felt no more of his fever. Three days after his last fit, being then employed on board of a ship in the river, he observed, at sun-setting, that all objects began to look blue, which blueness gradually thickened into a cloud, and not long after he became so blind as hardly to perceive the light of a candle. The next morning, about sun-rise, his sight was restored as perfectly as ever. When the next night came on, he lost his sight again in the same manner; and this continued for twelve days and nights. He then came ashore, where the disorder of his eyes gradually abated, and in three days was entirely gone. A month after, he went on board of another ship, and after three days stay in it the night blindness returned as before, and lasted all the time of his remaining in the ship, which was nine nights. He then left the ship, and his blindness did not return while he was upon land. Some little time afterwards, he went into another ship, in which he continued ten days, during which time the blindness returned only two nights, and never afterwards.

In the August following, he complained of loss of appetite, weakness, shortness of breath, and a cough; he fell away very fast, had frequent shiverings, pains in his loins, dysury, and vomitings; all which complaints increased upon him till the middle of November, when he died. He had formerly been employed in lead-works, and had twice lost the use of his hands, as is usual among the workers in this metal. Medical Transactions, published by the College of Physicians in London, vol. i. p. 60.

Pye,‡ servant to a miller, at the 6th mill on the Limehouse wall, about 40 years of age, came to me, October 2d, 1754, for advice and assistance. He told me, that about two months ago, while he was employed in mending some sacks, near the setting of the sun, he was suddenly deprived of *the use of his*

* Est immanis differentia inter splendorem et activitatem luminis candelæ et lunæ: luminis solaris vis est ad vim luminis candelæ 16 pedis distantis, observante D. Bonguer ut 11664 ad 1; et ad lumen lunæ in pleni lunio, ut 374,000 ad 1 demonstrante D. Euler Mem. de l'Acad. de Berlin, an. 1750, pag. 299. non mirum itaque si vis toties major sufficeret ad succutiendam retinam quam tanto minor non afficiebat. *Sauvages Amblyopia Crepuscularis.*

† By Dr. Heberden.

‡ Case by Dr. Samuel Pye.

limbs and of his sight. At the time he was attacked with this extraordinary disease, he was not only free from any pain in his head or limbs, but, on the contrary, had a sensation of ease and pleasure; he was, as he expressed himself, as if in a pleasing dose; but perfectly sensible. He was immediately carried to bed, and watched till midnight; at which time he desired those who attended him, to leave him, because he was neither sick nor in pain. He continued the whole night totally blind, and without a wink of sleep.

When the day-light of the next morning appeared, his sight returned to him gradually as the light of the sun increased, till it became as perfect as ever; when he rose from bed, his limbs were restored to their usual strength and usefulness, and himself in perfect health.

But on the evening of the same day, about the setting of the sun, he began to see but obscurely, and his sight gradually departed from him, and he became as blind as on the preceding night, though his limbs continued as well as in perfect health; nor had he, from the first night, any complaint from that quarter.

The next day, with the rising sun, his sight returned; and this has been the almost constant course of his disease for two months past. From the second night, the symptoms preceding the darkness were, a slight pain over the eyes, and a noise in his head, which he compared to a squashing of water in his ears.

After near two months continuance of the disease, on September the 29th, the patient was able to see all night; on the 30th September, October 1 and 2, he was again blind all night; on the 3d, he was able to see; on the 4th, he was blind till 12; on the 5th, was blind. From this he had no return of his complaint till June, 1755; from which till the 3d of October, when I again saw him, he had three or four attacks; from the 3d till the 10th, he had an attack every evening.—He had at this time a purging. I ordered him an electuary of bark and nutmeg, which succeeded in removing the blindness; but the diarrhœa continued wasting him. On the 20th, delirium came on; on the 21st, he became deaf; he died on the 25th, after having suffered from fever, pain in his bowels, and continued diarrhœa; but the defect in his eyes never returned after the 10th. This man had clear, bright eyes; when his sight failed him the pupils were enlarged about one-third in diameter. Medical Facts and Enquiries, vol. i. p. 111. I could give other cases from my note-book, but these are sufficient.

Boerhaave gives us an example of imperfect vision, from a discordance betwixt the contraction of the iris and the excite-

ment of the retina; so that the pupil did not dilate in the proportion to the decay of light.*

When inflammation extends within the eye, or when the retina is excited by sympathy with the ophthalmia of the outer membranes, it may happen that the patient is totally blind during the day, and yet sees on the approach of evening; because, from the sensibility of the retina, the pupil is absolutely shut, but as the light is diminished the pupil is gradually relaxed, and the obscure light admitted; and this obscure light, from the irritable state of the retina, gives a vivid sensation incomprehensible to the bye-standers. Our judgments of the strength of sensations are comparative merely; when we have been accustomed to strong impressions, lesser ones are disregarded. The greater light destroys the capacity of the retina for receiving slighter and more delicate impressions; while, on the other hand, the absence of light reserves to us the power of seeing objects the most faintly illuminated. We are every day becoming more acquainted with the invisible properties of light; and we have frequent experience of darkness being relative, and that what we should call total darkness is very often but a fainter light. One man will see distinctly, when another is quite deprived of the power of discerning objects. A man in prison seems to have the light gradually admitted to him; and many animals are in quick pursuit of their prey, while we are groping our way with the assistance of our other senses.

Animals which seek their prey in a light which is darkness to us, have, most probably, a greater degree of sensibility of the retina. But they have also a more conspicuous apparatus in the largeness of their eyes, and the dilatability of their pupil, while the sensibility which this provision gives, is often guarded from the light of day by the membrana nictitans, and by an iris capable of great contraction. Their iris possesses also a great power of contraction in narrowing the pupil during the day, as it is capable of dilating during the night, to the whole extent of the cornea. In the human eye, also, the strict sympathy between the iris and retina is a guard to the latter. But it has often happened that, in using optical instruments, the retina has been hurt by the intensity of the light from the concentrated rays: a lesser degree of this effect we have given us in the following instance:†

"Being occupied in making an exact meridian, in order to observe the transit of Venus, I rashly directed to the sun, by

* In old people there is an obscurity of vision, from a diminished sensibility of the retina; and the iris does not take a quick succession of contraction and dilatation with the change of light.

† Viz. by Dr. Reid.

my right eye, the cross hairs of a small telescope. I had often done the like in my younger days with impunity; but I suffered by it at last, which I mention as a warning to others. I soon observed a remarkable dimness in that eye, and for many weeks, when I was in the dark or shut my eyes, there appeared before the right eye a lucid spot, which trembled much like the image of the sun seen by reflection from water. This appearance grew fainter, and less frequent by degree, so that now there are seldom any remains of it. But some other very sensible effects of this hurt still remain :—For, first, the sight of the right eye continues to be more dim than that of the left; secondly, the nearest limit of distinct vision is more remote in the right eye than in the other, although, before the time mentioned, they were equal in both these respects, as I had found by many trials; but, thirdly, what I chiefly intend to mention is, that a straight line in some circumstances, appears to the right eye to have a curvature in it. Thus when I look upon a music book, and, shutting my left eye, direct the right to a point of the middle line of the five which compose the staff of music, the middle line appears dim indeed at the point to which the eye is directed, but straight; at the same time the two lines above it and the two below it appear to be bent outwards, and to be more distinct from each other and from the middle line, than at other parts of the staff to which the eye is not directed. Fourthly, although I have repeated this experiment times innumerable within these 16 months, I do not find that custom and experience takes away this appearance of curvature in straight lines. Lastly, this appearance of curvature is perceptible when I look with the right eye only, but not when I look with both eyes; yet I see better with both eyes together than even with the left eye alone."

Herschel, in making his observations on the sun, found the irritation proceed from the red rays* (being those of the rays of light which have the property of producing heat in the greatest degree; he found, when he used red glass to intercept the too vivid impression of light on his eyes, that they stopped the light, but produced an insufferable irritation from the degree of heat. But when he used green glass it transmitted more light, and remedied the former inconvenience of an irritation arising from heat. He concluded, that in the darkening glasses for telescopes, the red light of the sun should be entirely intercepted. Boerhaave mentions an instance of the retina being injured by the long use of the telescope, and

* See a curious instance of red colours producing convulsions in an epileptic patient. Sandifort Thes. vol. iii. page 314.

he himself was hurt by a similar cause. These injuries are owing to the intrusion of light highly concentrated, and over which the pupil has no command ; it is a degree of intensity which the organ is not prepared to counteract.

CHAP. V.

OF THE MEMBRANA PUPILLARIS.

The membrana pupillaris is an extremely vascular membrane, which is extended across the pupil of the fœtus. It was discovered by Haller, Albinus, Wachendorf,* and Dr. William Hunter, at the same time or without correspondence with each other.

Haller,† after injecting, with oil of turpentine and cinnabar, a fœtus of the seventh month, saw through the cornea the vessels of the iris injected, and some ramifications from them produced into the space of the pupil. From conviction that no vessels ramified without an involving membrane, he naturally concluded, that a membrane was drawn across the pupil of the fœtus, though in this instance, it was about to disappear. In several other fœtuses of the seventh month he confirmed his first observation ; and, cutting off the cornea, he observed the membrane impelled forward by the humours behind, like a little vesicle.

Albinus, in his first book of Academical Annotations, thus describes the way in which he detected this membrane. In the same child in whom he had filled the vessels of the crystalline, he also first observed the membrane which closes the pupil, and in which the vessels were injected that came from the margin of the pupil. Upon looking through the cornea, he could see no distinction of parts, but all seemed vascularity. He conceived, at first, that these were the vessels of the uvea, and that it had quite contracted and had shut the pupil ; then that they were the vessels of the capsule of the crystalline lens ; but having cut into the eye, he found it to be this membrane. Dr Hunter, speaking of this membrane, and of Albinus's claim to the discovery, says, "In justice to this great anatomist, I must declare that I believe this, both because he

* In Commercio Norico, A. 1740, hebd. 18. as quoted by Haller.
† De nova tunica pupillam fœtus claudente. Oper. minor.

asserts it and because I know from the circumstances it was hardly possible he could miss taking notice of it in that child." "I have always observed (he continues) both in the human body and in the quadruped, that there is a great resemblance to one another in the vessels of the capsula crystallini and of the membrana pupillæ. In an injected fœtus, I always find both nearly in the same state: if one be filled only with the blood that is drove before the injection, so is the other; if one be filled partly with injection, and partly with blood, the other is in the same condition: if one by good fortune be finely and minutely filled with injection, the other is so too; if one be burst by extravasations, the other is commonly in the same state; and when the fœtus is so near its full time that the one cannot be injected, neither can the other."*

Dr. Hunter, speaking further of the artery of the crystalline capsule, says, "that it does not terminate at the great circle of that humour. Its small branches pass that circle, and run a very little way on the anterior surface of the crystalline humour before the points of the ciliary processes; then they leave the humour and run forwards, supported on a very delicate membrane, to lose themselves in the membrana pupillæ." He continues: "The membrana pupillæ receives two different sets of arteries, one larger, from the iris, and the other much smaller, but very numerous from the crystalline capsule."

Now I think that every expression in these excerpts confirms the opinion I entertain, that these vessels which are seen filled with red blood, and which take their course through the humours, are subservient merely to the membrana pupillaris.

The first time I observed the membrana pupillaris was in the eye of a child born at the full time. I had injected the child very minutely with size and vermillion, and the iris was beautifully red and the pupil quite transparent and black, and not obscured by any extravasation of the injection into the aqueous humour: upon very narrowly observing the circle of the iris, I saw distinctly a small injected vessel pass out from the edge of the iris, and crossing the pupil, divide into two branches, which ran into the opposite margin of the iris. This was the remans of the membrane, but so delicate and so perfectly transparent, that the presence of it was only to be argued from the vessel which was seen to cross the pupil.

Since that time I have often seen it in the early months, and particularly strong about the seventh month of the fœtus. It is then an opaque, and very vascular membrane, and gene-

* See Medical Commentaries, p. 63. foot note.

rally it has spots and streaks of extravasation in it. The vascular structure of this membrane is very particular, and I can assign no other reason for this than that it may be a provision for its rapid absorption. It has evidently two sources of vessels, viz. the vessels of the capsules and those of the iris; but whether the arteries come by the one source, and the veins depart by the other, I cannot as yet determine. In one preparation I see the vessels with their trunk in the membrana pupillaris, and the branches sent over the surface of the iris.

The larger and flat venous-like vessels of the membrane are distributed in a beautiful net-work, in the form of the lozenge of a Gothic window. They have a free communication with each other. In their whole course the vessels seem nearly of the same size, (which also is like the character of a venous net-work,) and they terminate apparently in the margin of the iris.

The use of the membrana pupillaris I think sufficiently apparent, though I do not find that it has hitherto been understood. Haller makes a comparison betwixt this membrane, which closes up the pupil, and that matter which is accumulated in the passage of the ear in the fœtus. But there is no analogy.—As the waters of the amnios might otherwise be in contact with the membrane of the drum of the ear, and injure what necessarily is of a dry and arid nature, this matter accumulated in the ear of the fœtus defends it. But at the time, when the membrana pupillaris exists in its full strength and vascularity, no light is admitted into the eye—the fœtus is lying in its mother's womb. Towards the ninth month, the membrane has become transparent, and if not totally absorbed, it is torn by the first motion of the pupil and altogether disappears. It can therefore have no effect in obscuring the light, and preventing it from exciting in too great a degree the eye of the newly-born child. To explain the effect of this membrane then, we have only to consider that it is of the nature of the iris to contract its circular fibres during the operation of light, so as to close or nearly close the pupil; that, on the other hand, the pupil is completely dilated through the operation of the radiated fibres of the iris in darkness:—To the question, then, why it is not dilated during the fœtal state? The answer, I think, is decidedly this:—The iris is not loose in the fœtal state, it is connected and stretched to the middle degree of contraction and dilatation by the membrana pupillaris. Were the iris in a full state of contraction, during the life of the fœtus, it could not receive its full nourishment, proper degree of extension, and due powers; but being preserved stationary and extended, the disposition to contraction,

which it must have when the retina is without excitement, is counteracted, until it is about to receive, by the birth of the child, that degree of excitement which is to keep up the preponderance towards the contracted state of the pupil.

CHAP. VI.

OF THE HUMOURS OF THE EYE.

OF THE AQUEOUS HUMOUR.

The aqueous humour is perfectly limpid. The use which I have assigned to the aqueous humour explains its nature and the extent of the chamber which contains it, viz. that it distends the cornea and allows the free motion of the iris; it consequently fills the space between the lens and cornea. The usual description is, that it is lodged in two chambers; the one before the iris, called the anterior chamber of the aqueous humour, and the other behind the iris, called the posterior chamber of the aqueous humour.

This posterior chamber, was, at one time, conceived to be of great extent,* and authors spoke of depressing the lens into the posterior chamber of the aqueous humour.† It is found, now, that betwixt the lens and iris there is no space to which we ought to give this name of chamber.

Heister, Morgagni, and M. Petit (medecin) first demonstrated the extreme smallness of the posterior chamber, and after them Winslow confirmed the fact, that the iris moved almost in contact with the anterior surface of the lens.

M. Petit gave the clearest proof of the smallness of the posterior chamber, by freezing all the humours of the eye, and dissecting them in their solid state. Without this expedient it was impossible to prove the relative size of the two chambers; for, whenever the cornea was cut, the aqueous fluid escaped, and the lens pushed forward. When the eye was frozen, and then dissected, it was found that the ice, which took

* Viz. by Heister. They were called the first and second chambers by M. Brisseau.

† There certainly appears sufficient room for this in Vesalius and Briggs' plates: these plates have misled many.

the shape and dimensions of the anterior chamber, was much larger than that found in the posterior chamber;* indeed the latter was formed of a very thin flake of ice. The thin piece of ice in the posterior chamber indicated as much fluid only betwixt the iris and lens as might allow a free motion to the iris. These experiments were instituted in the course of investigating the question of the nature of the cataract.

The conclusion, that the posterior chamber of the aqueous humour contained but one-fourth of the whole aqueous humour, was admitted with great difficulty and after much contest. It determined the question, whether the cataract was a membrane of the opaque lens; for, as those who maintained that it was a membrane, said it could not be the lens, because the lens was far distant from the iris, it was necessary for their opponents to prove that the lens was close upon the pupil, and that the posterior chamber of the aqueous humour was very small.

It is agreed that in the adult, the quantity of the aqueous humour amounts to five grains; in the fœtus it is red, turbid, and weighs about a grain and a half, owing, in part, to the comparatively greater thickness of the cornea.

As it is natural to conceive that the aqueous humour flows from a vascular surface, it is the most generally received opinion, that it is derived from the points of the ciliary processes and surface of the iris. Haller, particularly, and after him Zinn, have thought that the ciliary processes were the secreting bodies; but there is one argument which, in my mind, determines that these are not the sole secreting parts, viz. that while the membrana pupillaris closes up the communication betwixt the two chambers, I have observed the anterior one to be full of the fluid, which of course must have been supplied from another source than the ciliary processes. I suppose, therefore, that the villous surface of the iris is the proper secreting surface of the aqueous humour.† Zinn observes, that Haller saw the membrana pupillaris distended and bulged forwards by the aqueous humour in the posterior chamber. It is scarcely necessary to say, that this must always take place when the cornea is first opened in demonstrating that membrane, whether there be a watery fluid behind it or not. But I believe I shall be able to prove, that the secretion of the ci-

* See Acad. Roy. des Sciences, 1723. Mem. p. 38.

† The opinion of Nuck is now out of the question. He thought that he had discovered particular aqueducts, which conveyed the aqueous humour into the anterior part of the eye; but these are found to be nothing more than the short ciliary arteries which pierce the forepart of the sclerotica. M. Merry and Bonhomme (see Zinn, p. 143.) observed, in an adult, the pupil closed with the membrane, and in this instance there was scarcely any fluid in the anterior chamber, whilst the posterior was turgid with fluid.

liary processes can have little power of filling the posterior chamber, even from the connection of membranes behind the membrana pupillaris in the fœtus. The aqueous fluid is perpetually undergoing the change of secretion and absorption, and this is the reason of its quick renewal when it has been allowed to escape by puncture of the cornea. The ancients were not ignorant of the quick regeneration of this fluid. It was proved to the moderns by a charlatan, Josephus Burrhus (ventosus homo, qui in carcere Romano periit.) Before the physicians of Amsterdam he punctured the cornea of a dog; then instilling his liquor under the cornea, he bound up the eye; in a few days he took off the bandage, and showed them the cornea again distended with the aqueous humour. It was soon found that the instilled fluid was of no kind of consequence. Redi and Nuck made many experiments, and it was found that the aqueous humour was regenerated in the course of 24 hours.

When the disputes regarding the cataract ran high, and when, to make new distinctions in the disease was taken as a mark of practical knowledge and of acuteness, there was a kind of cataract attributed to the aqueous humour. When the aqueous humour became turbid, white, and opaque, and obscured the pupil, they were absurd enough to call this a cataract. The turbid state of the aqueous humour is at once distinguishable, from the opaque lens, because it obscures the iris as well as the pupil.

Pus is formed in the chambers of the aqueous humour, in consequence of deep inflammation, contusions, &c. and from the same cause, sometimes, proceeds a bloody effusion. When the pus has lodged in the anterior chamber of the aqueous humour, it would appear, upon the authority of Galen, that an oculist of his day performed a cure by shaking the patient's head!* It is an operation of oculists to puncture and allow the pus to flow out, and some have even syringed out the pus with water;† but this must have been on the principle of Jos. Burrhus's exhibition; for the natural secretion is here the best diluent. When we recollect the nature of the parts with which the pus lies in contact, we cannot be sanguine in the hope of such an operation saving the eye. Sometimes there remains,

* Mouchart says, he has often seen the oculist Woolhouse repeat this cure by shaking his patient's head over the side of the bed. He attributed the cure to the falling of the pus into the posterior chamber, which, he supposes, has parts more capable of absorbing it.

† They were at variance regarding the place at which to puncture for this discharge: Some did it behind the iris; there we know there is a crowd of vessels; the best place is the lower edge of the cornea before the iris. It seems to have been no uncommon accident, in this operation, to find the lens protruded through the pupil. The reason of this has been already explained.

after operation on the cornea, or in consequence of ulceration, a continued flow of the aqueous humour; the consequence is a subsiding of the cornea;* it becomes corrugated, opaque, and from the contact of the iris, apt to adhere to the iris. In consequence of this suppuration, there sometimes follows an absolute obstruction of the pupil, from the coalescing and adhesion of the edges of the iris.†

THE VITREOUS HUMOUR.

The vitreous humour, as already explained, occupies almost entirely the great ball of the eye. It is consequently beyond the lens, and keeps it at the requisite distance, to cause the rays from objects to concentrate and impinge upon the retina. The vitreous humour is considerably denser than the aqueous humour.‡ Its involving membrane is called membrana hyoloides sive vitrea.§ The peculiar appearance of this humour, its glairy-like consistence, is not owing to its density, but to the manner in which it is contained in its membranes. From being contained in a cellular structure of perfectly pellucid membranes, it has the adhesion and consistence of the white of an egg. This membranous structure of the vitreous humour has been demonstrated by acids and by freezing. When frozen, it was found to consist of pieces of ice connected by strong membranes, which separated with difficulty, and showed their torn fragments: and M. Demours lifted the transparent membranes with the point of a needle. Although the vitreous humour appears to be gelatinous, it is not so in reality, and when it is taken from the coats of the eye, it retains the shape for a time, but gradually subsides by the fluid exuding from the membranes, and this is accelerated by puncturing it.

OF THE CRYSTALLINE LENS.

The crystalline humour is a small body, of the shape of an optician's lens, of great power. It is of perfect transparency, and of density much greater than the vitreous humour. Its density to that of the vitreous humour is calculated to be as 1114 to 1016. But the crystalline is not of uniform density, for the centre forms a denser nucleus.

The form of the crystalline is that of a compressed sphere,

* Rhytidosis, seu subsidentia & corrugatio corneæ.
† Viz. Synisesis. There has occurred congenital imperforation of the pupil.
‡ It is, according to Dr. Monro, in the proportion of 1016 to 1000.
§ *Ophthalmographia* authore G. Briggs, 1676. Cantab.

the anterior surface being more compressed or flatter, though, in a degree, convex. According to Petit, the anterior surface is the segment of a sphere whose diameter is 7, 8, or even 9 lines. The posterior surface is a sphere of 4 or 5, or 5½ lines in diameter. The internal structure of the lens is quite peculiar, and resembles neither the vitreous nor the aqueous humour. By maceration it splits into lamellæ, and at the same time bursts up into equal parts, so that there is first a stellated-like fissure, and then it separates into pretty regular divisions; and after maceration in acids, the lens can be teased out into minute shreds and fibres.*

From it form, density, and central nucleus, it has great power of converging the rays of light; and in an eye properly constituted it concentrates them accurately to the surface of the retina. For this reason, it is placed before the vitreous humour, and socketed in its anterior part. It is contained in a capsular membrane, the *tunica aranea*, improperly called,† which membrane is continued from, or connected with, the membranes of the vitreous humour; but this is a subject which requires a more particular investigation.

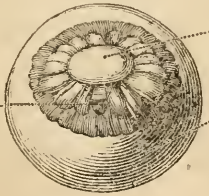
OF THE CAPSULE OF THE LENS AND VITREOUS HUMOUR.

Marginal Plate 13.

Fig. 2.

Fig. 3.

Fig. 1.



In fig. 1. we have the appearance of the Petitian canal blown up. It is not found full of any fluid, it is only the laminæ of

* See further of the muscularity of the lens.
† *Ophthalmographia.*

membrane inflated, and it is best demonstrated when the eye is slightly putrid by cutting off the cornea, and with it a small circular portion of the sclerotica, and taking with these the iris also, when the lens presents itself seated firmly in its capsule on the vitreous humour. Now laying back the ciliary processes, we make a fine puncture with a lancet by the side of the lens, and then blow gently into it with the blow-pipe.

Every anatomist acknowledges the existence of the Petitian canal, and a distinct capsule to the lens is also pretty generally allowed. But many deny that the vitreous membrane has two plates, without observing that the existence of the Petitian canal is a proof of the splitting of the membrana vitrea, on the forepart at least. Some believe that the vitreous membrane splits and involves the lens, and forms its capsule ; but the difficulty, on this supposition, is still to account for the formation of the canal which surrounds the lens ; for as the fluids on the surface of the lens and within its capsule have not admission to the canal, the canal must be distinct ; and, indeed, sometimes we blow up the circular canal, and sometimes, by a wrong puncture, the capsule of the lens itself ; but not both at once.

Seeing, then, that these cavities are distinct, some anatomists have admitted that the membrana vitrea is double ; that the lens has its proper capsule ; and that the lamina of the vitreous membrane, coming near the margin of the lens, splits and involves it in a second coat, (as in fig. 2.) Others have supposed that the anterior layer of the vitreous humour does not pass over the anterior surface of the proper capsule of the lens, but only adheres to the edge of the capsule of the lens, and forms the Petitian canal. There are yet others who have described the membrana vasculosa of the retina, as forming the capsule of the lens. This is one of those pieces of anatomy which provokes us to continued research, and mortifies us with continual disappointment. If this piece of anatomy, when investigated in the eye of an adult, is difficult to be understood, it is infinitely more complicated in the eye of the fœtus ; and, for my own part, I cannot reconcile my experience with any former opinion.

I conceive that it is the membrana vasculosa tunicæ retinæ, or membrana vasculosa Ruyschii, which forms the vascular capsule of the lens in the fœtus, and also the canal of Petit in the adult. The crystalline lens has, in the first place, its proper capsule, which surrounds it on all sides : again, the transparent web of membrane that is continued onward from that part of the retina which has upon it the pulpy and nervous expansion, splits when it approaches the margin of the lens. One lamina goes round behind the lens, and the other passes a

little before it, forms an adhesion to the capsule of the lens, and is then reflected off to the points of the ciliary processes and to the membrana pupillaris of the fœtus.* Betwixt these split laminæ of the continued membrane of the retina, the canal which surrounds the lens is formed. The membrana vitrea is simply reflected over the back of the lens, and has no part in forming the Petitian canal. Where the retina advances forward upon the ciliary processes, it forms an adhesion, beyond which the medullary part is not continued; but the membrana vasculosa passing onward, as I have described, embraces the lens, and the lamina, which passes behind the lens and before the vitreous humour, receives and conveys the artery of the capsule; on the forepart of the lens the anterior lamina only touches the capsule of the lens, adheres, and is then reflected off to form the membrana pupillaris.

In this account I am supported by the most careful investigation, and by the simplicity of this system of vessels: for it will be observed, that it is on the membrana vasculosa alone, that the vessels carrying red blood in the fœtus, are supported, and that it shows throughout the same character for vascularity. Again, I think it probable that this membrane which passes before the lens, viz. the membrana pupillaris, and that which passes behind the lens, forming the vascular capsule of the lens, disappear at the same time; or if this posterior and vascular membrane which passes behind the lens is not totally absorbed, it becomes thin and more intimately united to the membrana vitrea.

CHAP. VII.

OF THE DISTRIBUTION OF THE CENTRAL ARTERY AND VEIN OF THE RETINA.

I AM the more anxious to give the accurate distribution of these vessels, that Walter's account of them has tended much to derange that simple and natural view of this system which observation authorizes us to take.

The arteria centralis retinæ arises from the ophthalmic ar-

* In the fœtus, as far as I have observed, the proper capsule of the lens and the membrana pupillaris, lie in contact, but they do not adhere; and while the membrana pupillaris is perfectly red with injection, there is none to be seen on the forepart of the capsule. There is, indeed, no part of that surface which is afterwards to secrete the aqueous humour, which could secrete that fluid, betwixt the surface of the lens and membrana pupillaris; so complete is the adhesion of the adventitious and vascular tunic of the lens to the membrana pupillaris.

tery.* Sometimes it is derived from the ciliary arteries before they enter the coats of the eye, and often there is more than one branch entering the optic nerve.† Arising from this source, there are many branches which are distributed to the retina, while a branch passes onward from the lamina cribrosa through the vitreous humour to the capsule of the lens. This vessel does not pass exactly in the centre of the vitreous humour, but to one side of the axis of the eye. When it arrives near the capsule of the lens, it divides into three or four branches, which, reaching the capsule, spread beautifully on the back part of it.‡

The BRANCHES of the arteria centralis retinæ, which are distributed in the retina, are subservient to its support, and are consequently as visible in the adult as in the fœtus; and, where the membrane of the retina has been described as adhering to the point of the ciliary body, these vessels of the retina unite to or inosculate with the vessels of the ciliary processes.

Walter objects to the description of the arteria centralis retinæ given by Haller and others; he says, decidedly, that there are no arteries distributed to the retina, and that anatomists have deceived themselves in supposing those vessels which ramify on the retina, to be arteries, when, in reality, they are veins; he conceives, that the free return of the injection from the extremities of the arteries into the veins has misled them.

I am at a loss to conceive what notions Professor Walter can have entertained regarding this vein distributed in the retina, without an accompanying artery. It is a supposition contrary to the general frame of the economy, and I would oppose to it, with confidence, my own experience, since in the ox and other animals, I have seen the veins of the retina turgid with blood and exceedingly distinct; yet, when I injected the trunk of the artery at the root of the optic nerve, I found a set of vessels injected on the surface of the retina quite distinct from the turgid veins, and which could be no other than the arteries distributed to the retina. I must conclude that there is no peculiarity in the distribution of vessels in the tunica vasculosa retinæ.

We frequently observe, that the trunks of veins and arteries,

* See Haller, Fascic. vii. tab. vi. fig. 2. 4. 7.

† Haller, F. vii. p. 42.

‡ Walter (de venis oculi) says, the arteria centralis retinæ, having perforated the membrana hyoloidea, passes through the middle of the vitreous humour, and scatters some twigs on the small cells of the vitreous humour. It does not, he says, run through the vitreous humour in a straight line from behind forward, nor does it divide into a great number of branches in the posterior part of the capsule of the lens, like radii from a centre, as Zinn has described. He asserts that the lens receives its vessels from the investure of the membrana hyoloidea, and that they run back from the edge of the lens towards the posterior convexity.

destined to the same final distribution, take a different course; but in their final distribution, I know no instance in which they do not ramify with parallel branches interwoven with each other.

The VENA CENTRALIS RETINÆ, as it is described by Haller, is sometimes a branch of the ophthalmica cerebralis, but often it rises from the cavernous sinus, amongst the origins of the external and inferior recti muscles of the eye; after giving off many small twigs to the periosteum and fat of the orbit, it passes obliquely from behind, forward and inward, perforates the sheath of the optic nerve, and, after supplying the sheath, dips into the surface of the nerve.—It is now the comes arteriæ centralis retinæ. It enters through the cribriform plate of the optic nerve, and spreading generally in large and remarkable branches on the retina, these make free inosculations with each other, and finally inosculate with the veins of the ciliary processes.

Whether a branch of the vena centralis retinæ is sent off to accompany the branch of the artery which takes its course through the vitreous humour, I have not been able to determine.

CHAP. VIII.

OF THE VASCULARITY OF THE PELLUCID MEMBRANES.

If we cut through the sclerotic and choroid coat, round the optic nerve as it enters the eye, and afterwards cut up the outer coats towards the cornea, the humours fall out from these coats, and will remain suspended in a fluid, hanging by the optic nerve, and closely embraced by the retina: we have now to review these parts taken collectively, independent of the outward and proper coats, and as I have classed them, as constituting the internal globe of the eye.

The first peculiarity which strikes us here is the perfect transparency of all the parts within the embrace of the retina. As there are, in the adult and healthy eye, no vessels to be seen in the transparent membrane and humours, it becomes a question, whether nature has provided for the support and nourishment of those parts by other means than the common circulation of red blood through vessels? Now, I am inclined to think, that there is no such circulation through them; and I believe, that this would be much more generally allowed were there not something like a proof remaining in men's minds that

these humours and tunics were supplied with red blood in the fœtus; whence they deduce the natural consequence that, in the adult state, these vessels are only shrunk so as to convey only colourless fluids. I have, therefore, to give my reasons why I think that these vessels of the fœtus are not subservient to the humours; and, I think, I shall prove that, when they have once disappeared, they are no longer pervious vessels; that, though those parts which they are supposed to supply, should become inflamed and vascular in the adult, these vessels which were apparent in the fœtus do not become enlarged; that they do not administer in any way to inflammation and disease, but that a new source is given, and that vessels are formed which were at no former period discernible.

Why should there be red blood transmitted to the pellucid membranes and humours of the fœtus? Why is not that state of circulation, which nourishes and supports the parts in the adult state, sufficient for their growth and the progress to perfection which they undergo in the fœtus? Why is the capsule of the lens only crowded with vessels carrying red blood, while the proof of vessels passing to the cells of the vitreous coat stands upon some very rare and vague assertions, and such as can be naturally explained by the appearance of those vessels which merely pass through the vitreous humour for a different destination?

I believe this is a view which has been little attended to; but, upon the most minute inquiry, and upon examining the preparations of the vascularity of the eye of the fœtus, I can see no vessels passing into the humours and carrying red blood, which are not finally distributed to the membrana pupillaris. When we lay open the eye of a fœtus, after a very minute and successful injection, we see vessels which all proceed from the centre of the optic nerve, passing through the vitreous humour to the back of the capsule of the lens, viz. the branches of the arteria centralis retinæ. This artery divides very often into many branches before it arrives at the capsule of the lens; now, if these be filled with blood, or but partially injected, they have the appearance of being branches distributed to the vitreous humour, and not to the lens. This appearance is still more apt to deceive us when the lens is separated from the vitreous humour, and when the vitreous humour is otherwise disturbed, for then the vessels shrink and seem to terminate in the midst of the vitreous humour. When the injection is perfect there is no such appearance.

On the back of the lens we see a profusion of vessels; but I think I may positively say that these vessels do not penetrate to the lens itself, but are merely on the capsule, and that hav-

ing made the circuit of the lens, they terminate in the membrana pupillaris and ciliary body. I can observe no villi on the inner surface of the capsule of the lens, nor any appearance of its being a secreting surface, to lead me to suppose that these vessels secrete the lens, as Walter supposes they do; nor, after the most successful injection of the capsule of the lens and of the coats of the eye in general, can I observe the slightest stain of colour in the pellucid state of the lens, nor betwixt its white fibres when it becomes opaque. Nor have I observed, at any time, a single branch of these vessels, which are so profuse on the back of the lens, distributed to the anterior part of the capsule; on the contrary, they all terminate abruptly at that line, a little forward from the utmost verge of the lens, where they are united to the vessels of the membrana pupillaris and ciliary processes. Were these vessels of the capsule provided for the secretion of the lens, or were those vessels the trunks of lesser branches, which pierce into the substance of the lens, they would appear also on the forepart of the capsule.

If I am accurate in these observations, we are authorized to deduce this conclusion:—that these vessels which we see running through the vitreous humour and capsule of the lens, and which are sometimes seen filled with red blood or injected with size and vermillion, are not the vessels of the humours, but vessels in their passage to the membrana pupillaris, and that they disappear totally when that membrane is absorbed. They are injected when the membrana pupillaris is injected; they are more difficult to fill when that membrane is becoming pellucid and tender towards the latter period of gestation; and with the annihilation of the membrane follows the disappearance of the vessels carrying red blood through the transparent humour of the eye.

In confirmation of the total annihilation of these central vessels of the vitreous humour, I have found that, when disease comes upon the lens of the adult, the vessels, which are apparent in consequence of inflammation, do not proceed through the old tract from the centre of the optic nerve and through the vitreous humour to the lens, but that they come from the extremity of the retina and laterally, and thence spread over the back of the lens.

An eye, which I had lately an opportunity of examining, confirmed me in this opinion. I assisted my brother in an operation on the eye, in which, the anterior part being diseased, it was cut away. I had soon an opportunity of retiring and examining the parts with Dr. Monro. I observed then an opaque spot on the posterior surface of the lens, which was

indeed in the capsule, and to this spot there came vessels over the margin of the lens from the extremities of the vessels of the retina; but, in the vitreous humour, there were no vessels to be seen, nor any branches passing into the lens obliquely from behind, as they do in the fœtus.

CHAP. IX.

SOME SURGICAL OBSERVATIONS CONNECTED WITH THE ANATOMY OF THE HUMOURS.

I HAVE already mentioned, as the principle of the operation of extracting the lens, that the simple action of the muscles, surrounding the eyeball, is sufficient to protrude the lens, if the incision of the cornea be of proper dimensions relative to the size of the lens. No doubt, if there have been thickening inflammation, and perhaps preternatural adhesions of the membranes surrounding the lens, the operation will necessarily become more complicated; the lens will not glide at once over the cheek when the incision of the cornea is completed. But still, I think, we are not to allow ourselves to consider it as a step of the operation, in any circumstances, that the ball of the eye is to be pressed; because, in that case, the membranes of the lens give way suddenly, and part of the vitreous humour unavoidably is protruded with it, or the edge of the lens is turned obliquely to the pupil, and the vitreous humour escapes by the side of it. It is better to destroy the adhesions with the instrument, and to scratch the capsule of the lens so that it may burst. Whence it is evident that it is necessary, in order to insure the correct performance of the operation of the extraction, that the lens should press equally forward on the pupil, and that the pupil should be allowed to dilate. From this it appears, how loose the ideas of those are who can speak of trying first to couch, and if that is not found to succeed, then to perform the operation of extraction. I conceive the attempt with the needle to preclude the operation of extracting, for these reasons:—An unsuccessful attempt to depress will, in general, be a laboured and reiterated motion of the point of the needle, which must occasion inflammation, and an adhesion firmer than is natural. Again, in couching, the lens is removed from the axis of the eye so far only, that, in the case of the

extracting being attempted, it no longer equally opposes itself to the pupil, the consequence of which must be, the escape of the vitreous humour and the detention of the lens.

In regard to the place at which the couching needle is to be introduced, we may observe, that we are directed by the older surgeons, to pierce the sclerotic coat very near to the edge of the cornea, because they were afraid of hurting the lens with the needle! The idea then entertained was, that the cataract was a membrane hung behind the pupil and before the lens. The older surgeons had the idea that the needle entered before the lens, and passed at once into the aqueous humour. We are to disregard these injunctions of surgeons who directed the needle to be introduced with the idea of avoiding the lens; for, while their notions regarding the disease were erroneous, their rules of operating could not be correct; accordingly, we find them differing in their directions as to the place of piercing the cornea; some directing us to pierce it at the distance of one line from the edge of the cornea, others at the distance of four lines and a half.

Now that we know the place of the cataract, and know also that it is the opaque lens, we can be at no loss to introduce the needle correctly. If, says M. Petit, we pierce the sclerotic coat one line from the edge of the cornea, we pierce the tunica conjunctiva, sclerotica, choroid, vitreous humour, and ciliary processes before the needle enters the cataract. In this puncture, we wound the most vascular part, and, indeed, every delicate part of the eye; for even in this most anterior course, the retina is equally lacerated with the others.* But if we pierce the sclerotic coat, three lines from the edge of the cornea, we avoid the ciliary ligament and body, and processes; and by directing it a little forward, in a line towards the opposite margin of the iris, we shall find the point of the needle advancing through the opaque lens; for, although the lens be so far opaque as to prevent the light from striking the retina, it is so far transparent, in general, that the needle is distinctly seen entering its substance, and can be then directed, so as to transfix the cataract without hurting the iris.

We have seen that there is no posterior chamber of the aqueous humour fit to contain the depressed crystalline lens. The belief, which even some modern surgeons have entertained, of the possibility of depressing the lens into the aqueous humour, is a remnant of those inaccurate notions respecting the size of the posterior chamber of the aqueous humour and the

* In our most modern system of surgery, we are directed to enter the needle one-tenth of an inch. To my certain knowledge, not only the ciliary body has been injured by this direction, but even the root of the iris has been seen to be pushed forward on the point of the needle.

place of the lens, which have long been corrected. With this, also, I think ought to have been forgotten, the idea of the rising of the lens after it has been depressed by the cataract floating in the humours.—The fact, I am confident, is this: when, after transfixing the cataract, we endeavour to dislodge it by depressing the point of the needle, we separate the adhesion between the humours and the points of the ciliary processes; we do not, however, unsocket the lens from the forepart of the vitreous humour, but when the lens descends with the point of the needle, from before the pupil, the vitreous humour revolves with it; the consequence of which is, that when the needle is withdrawn, the lens rolls rounds with the vitreous humour: but as the lens only is opaque, as its firm connection with the vitreous humour, and even the rolling of the vitreous humour itself cannot be seen, this rolling of the lens appears to be the consequence merely of its own buoyancy in the aqueous humour. This adhesion of the lens to the vitreous humour, I have been sensible of during its depression, from the elastic nature of the resistance which I felt. When the lens parts from its socket in the vitreous humour, and when it is depressed with such a turn of the needle as puts it under the anterior part of the vitreous humour, it cannot rise again; there is no motion of the eye which can replace it—there is no aqueous fluid in which, if it were of less specific gravity, it could rise; it lies under, and, in part, imbedded in the vitreous humour. Another idea is, that it rises with the needle: but no one, who understands what is to be done in the operation of the needle, will raise it again opposite to the pupil after the lens is depressed—it ought to be withdrawn without again elevating the point. But what has always appeared to me as the most unaccountable cause that can be assigned for the rising of the cataract, is the action of the muscles of the eye.* It has been explained how the lens is protruded by the action of the muscles when the cornea is cut and the aqueous humour let out, for then the uniform resistance of the eye is broken, and there is a motion of the humours towards the breach; and the lens lying behind the pupil, is the first part to be protruded forward; but when it lies under the anterior part of the vitreous humour (and there it must lie if it is at all displaced,) or in whatever situation it happens to be, from that it cannot be moved by the action of the recti muscles; for they embrace the eye on every side, and their action operates uniformly, so that they cannot affect a body immersed in the midst of the humours. For the same reason that we should decline the operation of extracting, after attempts have been made to de-

* See Mr. Benjamin Bell's System of Surgery.

press with the needle, I should refuse when the pupil is rugged and irregular, because the disease may be more extensive than it appears to be. Thus cataracts brought on by falls, or blows, or punctures of the eye, are less favourable, as there is danger of the inflammation having gone deep, and having affected the other humours in a way which cannot be known, since the opaque lens is betwixt us and them.

A frequent cause of the failure of the operation of depression is the displacement of the lens backwards; for when it seems to have gone down with the needle, it has slipped from under it and started backward. In this case the pupil appears clear, but the patient gains little advantage; for the cataract, though removed from the pupil, is still in the situation to obstruct the light.

CHAP. X.

OF THE MANNER IN WHICH THE EYE ADAPTS ITSELF TO THE DISTANCE OF OBJECTS.

This is a question which many have endeavoured to determine, and many have failed; the proof of this is, that there is not one explanation of the manner in which the eye adapts itself to the distance of objects, but many explanations equally ingenious.

One opinion is, that the eye is at rest when we see the distant parts of a landscape, but that the direction of the eye to the nearer objects is attended with an effort. This effort is the action of the straight muscles of the eye compressing the ball of the eye, so as to lengthen the axis as much as is necessary to allow the pencils of rays to unite in points upon the retina.

To this opinion it is objected, that in some animals the sclerotic is hard, and not capable of changing its figure; that in man, the pressure would be unequal; that the unelastic retina would be thrown into irregular folds; that these muscles, being voluntary muscles under the will, we should be more conscious of their operation than we are; and that, while the mind remains attentive to distant objects, no voluntary exertion of these muscles can affect the distinctness of the objects.

Again, to make the eye change its accommodation from the distinct vision of objects, at six inches to fourteen feet five inches, would require such a pressure as might lengthen the axis of the eye one-tenth part, which again would form an oval that would derange the retina.

Another opinion is, that when the eye sees the nearest objects it is at rest, and that, in attending to distant objects, the straight muscles draw back the forepart of the eye into the socket, and thus shorten the axis. To this opinion, of course, the same objections lie as to the supposition that the axis is lengthened by the operation of the muscles.

There are some who have entertained an opinion, that the iris, by its contraction, operates so on the circular margin of the cornea, where it is connected with the sclerotic coat, as to make the cornea more convex, and thus increase its power of concentrating the rays, and enable the eye to see near objects distinctly. To account for this power in the iris, Dr. Jurin, the proposer of this hypothesis, supposes that there is a greater muscular ring in the margin of the iris connected with the edge of the cornea; the existence of these muscular fibres is not demonstrated, but he says, since the lesser muscular ring in the inner margin of the iris is not proved by ocular inspection, and yet is justly inferred from its effects, viz. the contraction of the pupil; in the same way, "the change of "conformation in the eye has not yet been adequately ac- "counted for, but may be fairly made out by supposing the "existence of the greater muscular ring." His conclusion is in these words:—"When we view objects nearer than the "distance of 15 or 16 inches, I suppose the greater muscular "ring of the iris contracts, and thereby reduces the cornea "to a great convexity; and when we cease to view these "near objects, this muscular ring ceases to act, and the cor- "nea, by its spring, returns to its usual convexity suited to "15 or 16 inches. In which condition the elasticity of the "cornea on the one side, and the tone of the muscular ring "on the other, may be considered as two antagonists in a "perfect equilibrium."

To this opinion it is objected, that the iris is not rooted in the cornea, but in the sclerotic coat, which is firm in man, and inflexible in many animals. We have also to consider, that this delicate and invisible circle of muscular fibres has not only to contract the margin of the cornea, but, in this action, to alter the configuration of the whole eye. The eyeball is a whole equally distended, and no part of it can suffer contraction without a resistance from the whole of the coats: besides, in this case, the alternation of light and the brightness of ob-

jects would be perpetually obscuring the image, by the play of the iris causing an alteration of the focus of the cornea. But Dr. Jurin did not attribute the whole effect to the action of the iris. He thus explains the use of the fluid surrounding the lens and the membranous capsule :—When the eye is to be suited to greater distances, he supposed that the ligamentum ciliare contracts its longitudinal fibres, and, by that means, draws the part of the interior surface of the capsule, into which these fibres are inserted, a little forward and outward. By this action, he supposed that the fluid, within the capsule of the lens, flows from the middle towards the margin ; and, consequently, the centre of the capsule of the lens is reduced to a less degree of convexity ; and that the elasticity of the capsule, and the tone of the ligament, may be looked upon as two antagonists perfectly in equilibrio with one another. In the state of rest the eye is conceived, by Dr. Jurin, to be adapted to the middle distance ; by the increase of the convexity of the cornea, to be adapted to nearer vision ; and by the change in the capsule of the lens, to be fitted to distant objects.

To this last supposition it is objected, that there is a simplicity in the operations of nature ; that the change wrought upon the capsule of the lens is insufficient to account for the whole effect, and that, therefore, there is a presumption that it has no share in producing the change ; that there are no muscular fibres in the ciliary processes ; and, lastly, that this fluid, being of density, but little, if at all, removed from the aqueous humour, any alteration of its form can have but a very insignificant effect.

It has occurred to others,* that the oblique muscles of the eyeball, being thrown in opposite directions round it, they may have the effect of elongating the axis of the eye: Again, that the action of the orbicularis muscle of the eyelids, by compressing the eyeball, assists in accommodating the eye for seeing near objects more distinctly. Dr. Monro makes a set of experiments to prove the effect of the orbicularis muscle of the eyelids ; but I conceive that he has deceived himself, in ascribing to the compression of the eyelids an effect partly produced by a voluntary effort, but in a way which is not understood, and partly by the contraction and dilatation of the pupil, from the degree of opening of the eyelids. If he be right in his way of accounting for the effects produced in the experiments which he details, they ought to have the effect of precluding the necessity of all further hypothesis ; so fully does

* Hambergerus, Briggs, Keil, Monro

the action of the orbicularis muscle seem to him adapted to the end proposed. In the first experiment, when he opened his eyelids wide, and endeavoured to read a book, the letters on which were so near the eye as to be indistinct, he found that he could not do it. In the second experiment, keeping the head in the same relation to the book, he brought the edges of the eyelids within a quarter of an inch of each other, and then made an exertion to read, when he found he could see the letters and words distinctly. When I try this experiment I find the action of the eyelids to have no sensible effect, unless they are brought very close together: then I do indeed find that they have a most remarkable effect. But in this situation, the eyelids cover the cornea so much, that if they have any effect at all upon the cornea, it must be to compress and flatten it, and not to give it a greater convexity. The smaller the opening of the eyelids, the greater I found the effect; I conceive it to be produced by the optical effect of the eyelashes correcting the too great converging of the rays; and the same effect I found to be produced by the marginal hairs of two flat camel-hair brushes, although the eyelids were kept open. Dr. Monro concludes that, in this action of the eye, 1st, the iris, 2dly, the recti muscles, 3dly, the two oblique muscles, and 4thly, the obicularis palpebrarum, have all their share in accommodating it to the distance of objects, and in giving perfect vision.

Very ingenious experiments are made by Dr. Young,* to determine whether there be any change in the length of the axis of the eyeball. He considers it as necessary to account for the power of the eye in adapting it to the distance of objects, that the diameter should be enlarged one-seventh; its transverse diameter diminished one-fourteenth; and the semi-diameter shortened one-thirtieth of an inch. To determine this he fixed the eye, and at the same time he forced in upon the ball of the eye the ring of a key, so as to cause a phantom very accurately defined to extend within the field of perfect vision; then looking to bodies at different distances, he expected if the figure of the eye was altered, that the spot, caused by the pressure, would be altered in shape and dimensions; he expected that instead of an increase of the length of the eye's axis, the oval spot caused by the pressure of the key, resisting this elongation, should have spread over a space at least ten times as large as the most sensible part of the retina: but no such effect took place; the power of accommodation was as extensive as ever, and there was no perceptible change

* Philos. Trans. for 1810.

either in the size or in the figure of the oval spot. Again, he placed two candles so as exactly to answer to the extent of the termination of the optic nerve: he marked accurately the point to which the eye was directed; he then made the utmost change in its focal length, expecting that, if there were any elongation of the axis, the external candle would appear to recede outward upon the visible space; but this did not happen; the apparent place of the obscure part was precisely the same as before.

A favourite opinion of late has been, that the lens has a power of altering its degree of convexity, and thus accommodating itself to the distance of objects. As to the fibrous structure of the lens, there can be no doubt: first, it is rent by fissure, then split into lamina, and can be finally teased out into fibres.

This structure was first observed by Leuwenhoeck; he has these words:—" Porro vidi corpus cristallinum ex tam tenui-" bus coacervatis constare squamis ut ubi eas oculo dimetior, " dicere cogar, pluris bis millenis sibi invicem incumbere; " ubi enim corpus cristallinum ab ejus membranula seperas-" sem, ejus adhuc axis, ubi crassissimum erat, (non enim est " perfecte rotundum, sed aliquo modo planum) duas tertias " pollicis partes retinebat; ergo a centro ad circumferentiam " est tertia pollicis pars atque quoniam, ex dimensione mea " 600 pili lati pollicis quadrati, longitudinem conficiunt 200 pili " lati pollicis tertiam partem adæquare debent. Atque nunc " video ubi denæ squamæ sunt coacervatæ, eas capilli nostri " diametrum nondum adæquare; ergo his 10 cum 200 multi-" plicatis, sequetur, ut dictum, plures 2000 squamas in corpore " cristallino esse coacervatas. Porro vidi singulas has squamas " ex filamentis, concinno ordine juxta se positis, constare adeo " ut singulæ squamulæ unum filamentum sint crassæ; & ut " hanc substantiam fibros eam ex qua corpus cristallinum con-" stat ob oculos ponerem, eam lineis in circulum ductis quan-" tum pote designavi."

The fibrous structure and muscularity of the lens was brought forward by Descartes, as explaining some actions of the eye; but was again neglected, till more lately, that it has been revived by the insertion of Mr. Young's Observations on Vision, in the Philosophical Transactions.* The following are Mr. Young' observations on the appearance of the lens:—" The " crystalline lens of the ox is an orbicular convex transparent " body, composed of a considerable number of similar coats, " of which the exterior closely adheres to the interior. Each

* See vol. for 1793.

" of these coats consists of six muscles, intermixed with a ge-
" latinous substance, and attached to six membranous tendons.
" Three of the tendons are anterior, three posterior; their
" length is about two-thirds of the semidiameter of the coat;
" their arrangement is that of three equal and equidistant rays,
" meeting in the axis of the crystalline; one of the anterior is
" directed towards the outer angle of the eye, and one of the
" posterior towards the inner angle, so that the posterior are
" placed opposite to the middle of the interstices of the ante-
" rior; and planes passing through each of the six and through
" the axis, would mark on either surface six regular equidistant
" rays. The muscular fibres arise from both sides of each
" tendon; they diverge till they reach the greatest circumfer-
" ence of the coat, and having passed it, they again converge
" till they are attached respectively to the sides of the nearest
" tendons of the opposite surface. The anterior or posterior
" portion of the six viewed together, exhibits the appearance
" of three penniforme-radiated muscles. The anterior tendons
" of all the coats are situated in the same planes, and the pos-
" terior ones in the continuations of these planes beyond the
" axis. Such an arrangement of fibres can be accounted
" for on no other supposition than that of muscularity. The
" mass is inclosed in a strong membranous capsule, to which it
" is loosely connected by minute vessels and nerves; and the
" connection is more observable near its greatest circumference.
" Between the mass and its capsule is found a considerable
" quantity of an aqueous fluid, the liquid of the crystalline."

FIBROUS STRUCTURE OF THE LENS.

Fig. 14.

Mr. Young's fig.

Fig. 15.

Leuwenhoeck's fig.

Supposing that these are muscular fibres, from their closeness and direction, they would stand acknowledged as forming the strongest and most powerful muscle of its size in the whole

body; yet they act only on themselves, which requires the least possible degree of power. Again, how are they relaxed? What power is their antagonist? Mr. Young demonstrates not only the muscular fibres, but the tendons of the lens;* as if it were not evident that the lens acted merely on itself, which could require no concentrating of its fibres into tendons; for tendons are found in other parts of the body only where it is necessary to concentrate the whole power of the muscle so as to operate on one point.

We learn from Mr. Home,† that Mr. John Hunter had proved the lens to be laminated, and those laminæ to be composed of fibres; and upon the same authority, we learn that his opinion was in favour of the muscularity of its structure. Mr. Home wished to follow out this subject, by including it in the Croonian Lecture. Mr. Home found, with the assistance of Mr. Ramsden, that a patient, after the extraction of the cataract, still retained the power of adapting the eye to the distances of objects. Indeed, we must be well aware, that if a patient, after couching and extracting the lens, could only see at one given distance, an effect so very particular must have been long since observed. This was a conviction to Mr. Home and Mr. Ramsden, that the investigation was to be no further pursued in this tract, and they turned their attention, therefore, to the cornea.

Mr. Ramsden contrived an apparatus which, if the gentlemen engaged in the experiments have not deceived themselves, must put this question at rest. By Mr. Ramsden's ingenious contrivance, the head was fixed accurately, and at the same time a microscope was adapted to observe the changes in the convexity of the cornea, as the eye was directed alternately to near and to distant objects. In these experiments, the motion of the cornea became distinct, its surface remained in a line with a wire which crossed the glass of the microscope when the eye was adjusted to the distant objects, but projected considerably beyond it when adapted to the near ones, and the space through which it moved was so great as readily to be measured by magnifying the divisions on the scale, and comparing them. In this way it was estimated that it moved the 830th part of an inch (a space distinctly seen in a microscope magnifying 30 times,) in the change from the nearest point of distinct vision to the distance of 90 feet.

In the evidence from anatomical structure, I cannot think Mr. Home so happy. He was desirous of determining more accurately than had hitherto been done, the precise insertion

* See Philos. Trans. † Ibid.

of the tendons of the four straight muscles, so as to know whether their action could be extended to the cornea or not; he found them to approach within $\frac{1}{8}$ of the cornea before their tendons became attached to the sclerotic coat. But he did not stop here—he stripped off with them the anterior lamina of the cornea. Now as it is supposed, in these experiments, that the action of the recti muscles upon the sides and back part of the ball compresses the humours, and makes them flow forward so as to distend the cornea; if the extremities of the tendons be inserted into the edge of the cornea and even pass over it, as Mr. Home has demonstrated, their effect would be to flatten the cornea, by drawing out and extending its margin. This is a circumstance which Dr. Monro has remarked; and Dr. Monro has also, with more accuracy of observation, found "all the tendinous fibres of the recti muscles firmly attached to the sclerotic coat at the distance of a quarter of an inch from the cornea, and no appearance that any part of them, or that any membrane produced by them, is continued over the cornea."

Amongst the variety of opinions, the innumerable, ingenious, but contradictory experiments for discovering the manner in which the eye adapts itself to the distance of objects, I am, for my own part, much at a loss to determine which I should prefer. I have often doubted whether these experimenters were not in search of the explanation of an effect which has no existence. I have never been able to determine, why a very slight degree of convexity in the cornea of a short-sighted eye should be so permanent during a whole lifetime, notwithstanding the perfect elasticity of the cornea, and its being so adapted as to alter its convexity by the action of the muscles. Again, a near-sighted person, with the assistance of a concave glass, can command the objects to the distance of some miles, and with the glass still held to his eye, can see minute objects within three inches of the eye. Now I cannot conceive how the concave glass should give so great a range to the sight: as there can be no change in the glass, it must be the eye which adapts itself to the variety of distances; yet, without the glass it cannot command the perfect vision of objects for a few feet. Again, a short-sighted person sees an object distinctly at three inches distant from the eye; at 12 feet, less distinctly; and when he looks upon the object at 12 feet, the objects beyond it are confused, just as in other men's eyes; but when he directs his attention to the more remote objects, those nearer become indistinct. Now this indistinctness of the object, seen when he examines narrowly the objects beyond them, would argue (did we admit this muscular power

in the eye of adapting itself to objects,) that the cornea or the lens has become less convex, were we not previously convinced that the utmost powers of the eye could not bring the object at the distance of 12 feet, or any other intermediate distance, to be more distinctly seen than the fixed and permanent constitution of the eye admits.

I cannot help concluding, therefore, that the mechanism of the eye has not so great a power of adapting the eye to various distances as is generally imagined, and that much of the effect attributed to mechanical power is the consequence of attention merely. An object looked upon, if not attended to, conveys no sensation to the mind. If one eye is weaker than the other, the object of the stronger eye alone is attended to, and the other is entirely neglected: if we look through a glass with one eye, the vision with the other is not attended to. Now, objects, as they recede from us, become fainter and fainter in their colours, and the general effect upon the eye is different from those which are near; and as it happens that the mind must associate with the sensation before it be perfect, there is, consequently, an obscurity thrown over distant objects when we contemplate near ones; as, on the other hand, the images of near ones are not attended to when the mind is occupied with distant ones, although they be nearly in the line with the distant object examined.

CHAP. XI.

OF SEEING IN GENERAL.

The eye is certainly the noblest of the organs of sense. It is that with which we should part the most unwillingly, and of which when deprived we are most helpless. A celebrated philosopher says, how much more noble is that faculty by which we can find our way in the pathless ocean, traverse the globe, determine its figure and dimensions, delineate every region of it; by which we can measure the planetary orbs, and make discoveries in the sphere of the fixed stars! Again, how admirable is that organ by which we can perceive the temper and dispositions, the passions and affections of our fellow creatures; and, when the tongue is taught most artfully to lie and dissemble, the hypocrisy is discovered in the countenance! We often are able to detect what is crooked in the mind as well as

in the body! Yet, notwithstanding the perfection of the sense of seeing, much of this perfection is gained by the other senses, and particularly by that of touch. If the human body were motionless and inert, the sensation conveyed by the eye would be very imperfect; we should be able to conceive neither the distance nor the figure of objects. But, as it is, the distance of the object, joined with its visible magnitude, is the sign of its real magnitude; and the distance of the several parts of an object, joined with its visible figure, becomes a sign of its real figure. Without this combination of the original sensation with the acquired perception, we should see form and colour without having any idea of its distance, or of the convexity of an object; we should have no measure of its length, or breadth, or distance.

Upon other occasions, we are apt enough to acknowledge the powers of association. But the connection of ideas is in no instance more constant and secret than in the ideas conveyed by sight and touch. When a solid body is presented to view, we see only the light and shade; but this raises in our mind the associated ideas from the sense of touch, viz. solidity, convexity, and angularity, "the visible idea exciting in us "those tangible ideas," which, in the free and promiscuous exercise of our senses, usually accompany it. It is thus that we attribute to the sense of sight what is the act of the memory and judgment.*

We have seen that the picture of an object is formed in the bottom of the eye. It was formerly sufficient to say, that the mind contemplates this image. We should say now, that this image is conveyed into the sensorium by the optic nerve. This is an hypothesis merely; and we have no more consciousness of the object being in the brain or sensorium, than in any other part of the body; we may rather say, that the impression made on the organ, nerves, and brain, is followed by sensation, and that the intelligence is the joint operation of the whole.† Lastly, the metaphysician calls our sensations the signs of external objects; because the object itself is not presented to the mind, nor is there an actual resemblance betwixt

* See Dr. Jurin on Mr. Molyneux's problem, Smith's Append. p. 27.

† Euclid, and others of the ancients, contended that vision was occasioned by the emission of rays from the eye to the object. He thought it more natural to suppose, that an animate substance gave out an emanation, than that the inanimate body did. In 1560, the opinion was confirmed that the rays entered the eye.—The sensation was not always believed to be in the retina: it was by some believed that part of the sensation was to be attributed to the crystalline. Kepler, in in 1600, showed, geometrically, how the rays were refracted through all the humours of the eye so as to form a distinct picture on the retina; and also he showed the effect of glasses on the eyes. See further, regarding the opinions of the ancients, Boerhaave Prelect. Acad. tom. iv. p. 282.

the object and the sensation of it, but merely a connection established by nature, as certain features are natural signs of anger; or by art, as articulate sounds are the signs of our thoughts and purposes.

We are now naturally led to the consideration of some points, the full comprehension of which require the knowledge, both of anatomy and of the principles of optics.

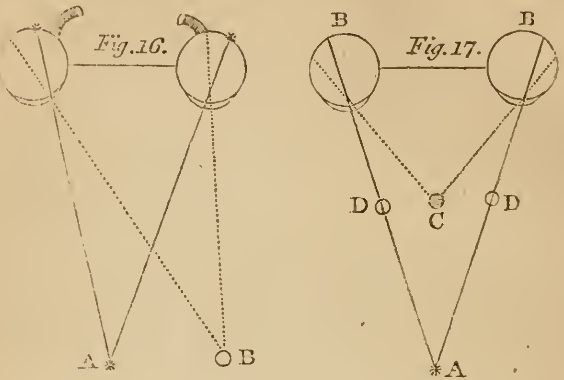
PARALLEL MOTION OF THE EYES.

The axis of the eye is a line drawn through the middle of the pupil and of the crystalline lens, and which consequently falls upon the middle of the retina; and the axes of both eyes produced, are called the optic axis. But the axes of the eyes, it is evident, are not always parallel; for when both eyes are directed to a near object, the axes of the eyes meet in that object; but when we direct the eyes to the objects in the heavens, they may be considered as perfectly parallel in their axis, though perhaps not then mathematically so. To an observer, the eyes seem always moving in parallel directions; but nature has given us the power of varying them so, that we can direct them to the same point, whether remote or near. This, however, is in some measure learnt by custom, and lost by disuse. A child has much difficulty in altering the distance of its eyes, which is the occasion of the vacancy of its stare: and again, we observe that a patient who has long lost one eye, is incapable of directing the axis of the blind eye without looking with the other, and even then, the blind organ does not follow the other with that perfect accuracy which exercise gives when both eyes are sound. By much practice and straining, the axes of the eyes may be much further altered from the natural parallelism, which wags and boys often do, so as to distort the eyes, and give a droll obliquity to the countenance.

Still, custom alters the direction of the axis of the eyes but a very little; for the natural constitution of the eye does not allow the child to turn his eyes in every different direction from each other. There is, on the contrary, as we have seen, a particular sensible spot in the retina, which makes it necessary to distinct vision, that this spot shall receive the concentrating rays of light; and the natural constitution of both eyes, is, that this spot in each eye shall have such a relation to that of the other, that the axis of both should be accurately in the middle of the eyeball in order to produce single vision.

By voluntary squinting or depressing one of the eyes with the finger, objects appear double, because the optic axis is changed in the distorted or depressed eye, and the picture is

no longer painted on corresponding points of both. This simple experiment leads us to consider what is the constitution and correspondence of the eyes, that when each has the picture of the object impressed upon it, we should only see it single if the eyes are sound and perfect.



For example, the object A, in fig. 16, is exactly in the centre of the axis of both eyes, consequently, it is distinctly seen; and it appears single, because the rays from it strike upon the points of the retina opposite to the pupils in both eyes. Those points have a correspondence; and the object, instead of appearing double, is only strengthened, in the liveliness of the image. Again, the object B will be seen fainter, but single, and correct in every respect. It will appear fainter because there is only one spot in each eye which possesses the degree of sensibility necessary to perfect vision: and it will appear single, the rays proceeding from it having exactly the same relation to the centre of the retina in both eyes. Though they do not fall on the centre of the retina, they fall on the same side of the centre in both eyes. But if the eyes are made to fix stedfastly on an object, and if another object should be placed before the eyes within the angle which the axis of the two eyes make with the first object, it will be seen double, because the points of the retina struck by the rays proceeding from the nearer object do not correspond in their relation to the central point of the retina. Thus, the eyes B B, fig. 17, having their axis directed to A, will see the object C double somewhere near the outline D D. Because the line of the direction of the rays from that body C, do not strike the retina in the same relation to the axis A B in both eyes. Upon this principle, we may easily explain why objects, which are much

nearer the eyes, or much more distant from them than that to which the two eyes are directed, appear double. Thus, if a candle is placed at the distance of ten feet, and I hold my finger at arm's length between my eyes and the candle, when I look at the candle, I see my finger double, and when I look at my finger, I see the candle double. This double vision occurs to us all frequently; but unless we make the experiment purposely, we do not attend to it. Many other instances of the harmony, and of the want of it, in the eyes, particularly the reverse of what these diagrams show, may be easily produced, viz. the seeing two objects single: for, if we look at a half-penny and a shilling, placed each at the extremity of two tubes, one exactly in the axis of one eye, and the other in the axis of the other eye, we shall see but one piece of coin, and of a colour neither like the shilling nor like the half-penny, but intermediate, as if the one were spread over the other.

This relation and sympathy between the corresponding points of the two eyes, is, therefore, to be considered as a general fact, viz. that pictures of objects falling upon corresponding points of the two retinas, present the same appearance to the mind as if they had both fallen upon the same point of one retina; and pictures upon points of the two retinas which do not correspond, and which proceed from one object, present to the mind the same apparent distance and position of two objects, as if one of those pictures were carried to the point corresponding with it in the other retina.

Several animals, we see, direct their eyes by very different laws from those which govern the motion of ours; but we are not to reason upon their sensations by the laws of vision of the human eyes: we must take it as a principle, that nature has been bountiful to them also; and that the result of organization in their eyes is perfect vision.

In birds, (if we except the owl,) the eyes diverge, and are directed to opposite sides. As the owl seeks his prey in the night, it may be necessary to the distinctness of his vision in weak light, that both eyes be directed to the object. Most fishes have their eyes directed laterally, though there are exceptions; as those fishes which are flat, and swim at the bottom, have their eyes directed upward. In many insects, the surface of the eye has no resemblance of the cornea of viviparous animals; but when examined with the microscope, it is seen to consist of a number of tubercles, each of which is a distinct eye. In others the eye is removed to the extremity of the moveable tentaculæ. Very large animals, as the whale, elephant, rhinoceros, hippopotamos, have, in proportion to their bodies, very small eyes: so have the animals which live

much under ground; and, in general, a large eye is a sign of the animal being able to see in obscure light, because there is proportionably a greater number of rays admitted into the eye. For the same reason fishes have a peculiarly large eye and dilatable pupil, because the water is a more obscure medium, and, from the occasional roughness of its surface, much darkened and variable.

We must conclude, that in these varieties of the eyes, where there is a difference in number, position, and natural motion, there are different laws of vision adapted to these peculiarities and the exigences of the animals. If we are to judge from analogy, we may suppose, that in many animals, there is no correspondence between points of the two retinas, or it is of a different kind from ours. In those which have immoveable eyes, the centre of the two retinas will not correspond so as to give the idea of one object, but of distinct objects, and in their respective places. In other animals, corresponding points would give false appearances; and in such as turn their eyes in all directions, independently of each other, they would seem to possess a perception of the direction in which they move them, as we have of the motion of our arms.

SQUINTING.

We have seen, that there is a point in both retinas more acutely sensible to the impression of light and the image of objects, than any other part of all its concave surface. In a sound eye, this point is immediately opposite to the pupil. There is a coincidence betwixt this point and the axis of the eye; and when we look to an object, its image strikes this point of the retina: but if it should happen that this sensible point of the retina should be changed, and not be exactly opposite to the pupil when the axis of the eye is in the line with the object, there will be an effort of the muscles moving the eyeball to turn, so that the rays proceeding from the object shall strike upon the more sensible spot of the nerve.* Again, if the greater sensibility of the nerve should lie in its proper place, and a remote cause should occasion such an action of the muscles and distortion of the eye as we see in a squint, then the image will be double, for it no longer falls on corresponding points of the retina of each eye, and separate images are conveyed to the brain. If, however, this distortion continues,

* This was M. de la Hire's opinion.—He had an idea also that squinting was produced by the obliquity of the object. Both of these opinions are refuted by Dr. Jurin.

the single vision is gradually restored. Is there, then, in this case produced a new correspondence betwixt points of the retina which were before discordant? We find that this is not the case, by a very simple experiment. In a person who squints, one of the eyes is directed to the object and the other appears to be turned from it: if the sound eye be shut, and the person be directed to look to an object with the other, it is directed to it with the proper and natural axis. Now this shows us that the sensibility of the proper spot in the bottom of the eye is not lost. We must explain the single vision in eyes, one of which is distorted from its natural axis upon another principle. Most people who squint, have a defect in one eye, and this is the distorted eye, while the other is directed in the true axis to the object. Now the mind does not attend easily to two impressions, the one being weaker than the other: in a short time the weaker impression is entirely neglected, and the stronger only is perceived.—So in squinting, the impression on the weak eye in a short time ceases to be attended to, the strong and vivid impression is alone perceived, and single vision is the consequence. It is evident, then, that those who squint must have a degree of imperfection in the strength of the image; for it is necessary to neglect the impression of one eye, to obtain distinct vision with the other; the consequence of this is frequently an attempt still further to distort the eye, and turn it so far inward or under the upper eyelid that no distinct impression can be received upon it: at all events they perceive the object only with one eye, although they may be said to see it with both; the perception being the combined operation of the organ and of the mind.

If the sensation of one eye be weak, it is very liable to be neglected altogether, and that eye is apt to wander from the true axis; and if the person be careless, or given to distort his eyes in childishness, a permanent squint may be given to the eyes.

Another cause of squinting, in children, is the being so laid in their cradle, that the light strikes obliquely into one of the eyes, whilst the other cannot see it; by which means one of the eyes only comes by degrees to be directed to the light, whilst the sensation of the other is disregarded. What is very extraordinary in squinting, is the correspondence in the muscles of the eye, notwithstanding the great distortion of the eyeball; for, when both eyes are open, as the sound eye turns in all variety of directions to the surrounding objects, the other eye still follows it, but preserves its distance, so as in a manner to avoid all interference. Blows on the head, drinking and smoking, and a variety of irritations, occasion-

ing convulsions and distortion of the eyes, cause double vision. As this is evidently produced by the affection of the muscles moving the eyeball,* since any change upon the retina could not give occasion to such distortions in a state of insensibility, we may naturally conclude, that squinting is sometimes the consequence of irregular action of the muscles; for if those transient causes are apt to effect them, so will they be apt to be permanently affected.†

We can distort our eyes by unnatural effort, but we cannot squint; that is to say, we can bring our eyes into such a forced situation that we cannot see any thing distinctly; but we cannot keep one eye distinctly upon an object, and turn the other from it.—Such a position of the eyes, at least, (and which is exactly that of those who squint unintentionally,) I cannot, by any means, accomplish.‡ This shows the strict correspondence betwixt the moving muscles of the eyeballs. By this experiment, we shall find the difficulty of that method of correcting the squint proposed by Dr. Jurin, or of commanding motions of the eyes different from those which have been bestowed by nature, or acquired by habit. But habit I believe to be much more seldom the origin of squinting than is generally supposed. It is said, by Dr. Reid and others, that we see young people, in their frolics, learn to squint, making their eyes either converge or diverge when they will to a very considerable degree: why should it be more difficult for a squinting person to learn to look straight when he pleases? The reason of the greater difficulty is obvious, that in making the eyes converge or diverge the will is acting upon both eyes equally; but to distort one eye inward or outward, and at the same time to keep the other fixed, is to me like an absolute impossibility. Most people, who squint, have a defect in the

* The command of voluntary muscles is first lost in intoxication; and, therefore it is more likely that the muscles should lose their natural action and correspondence than the retina.

† In Smith's Optics, there is a case of squinting and double vision occasioned by a blow. In Buffon's Dissertation, in the Acad. Roy. des Sc. 1743, squinting after long continued pain of the head. In the Mem. Roy. de l'Acad. des Sc. 1718, Hist. p. 29, there is a curious instance of false vision. I find also quoted several cases of strabismus from sudden fright, in *Ephem. Germ. cent.* 3. & 4. *obs.* 152. *p.* 349. Ib. dec. 3. an. 8. & 11. ob. 57. d. 114. Ib. dec. 3 an 9 & 10. obs. 67. "Novi Juvenem paralysi obnoxium, cui cum cæteris oculi sinistri musculis relaxatis, *adducens* fortius contraheretur propter oculum ita distortum objectum quodcunque duplex apparebat, nec quod verum esset distinguere potest." *Willis de anima Brut. P. Physiol.* p. 77. An instance of the loss of corresponding motions of the eyes, and strange illusions of sight. See in the Enquiry into the nature of mental derangement by Dr. Crichton, vol. i. p. 147.

‡ It is said that astronomers, who are much used to attend only to the impressions of one eye, are sometimes able to squint at pleasure. See Mr. Home, Phil. Trans. 1797, p. 17.

distorted eye, a weakness which they do not observe, from want of attention to the impressions upon that eye. It will be difficult to determine whether this defect be an original fault, or the effect of the want of use; since, by tying up the sound eye, the weak one becomes gradually stronger, so that the person becomes able to read with it: much may be attributed to the neglect of impressions.

It may be observed, that this neglect of the impressions, which are actually received, is not at all like that disuse, which is the consequence of no impression being received: for darkness increases the sensibility of the retina, while this dissipates and exhausts it. That squinting is not produced by the weakness of the impression received upon the nerve, would appear from the circumstance that opacity of the humours or the gutta serena do not occasion an alteration of the usual correspondence in the muscles moving the eyeballs.

It is said, that in those who have lost the sight of one eye, the habit of directing it to the object they look at is lost, because this habit is no longer of use to them.* This I have never observed, nor should I think it apt to happen, unless the muscles of the eye had been injured from the same cause which destroyed the sight; at any rate, it is in a very imperfect degree, and not such as we should call a squint.

In regard to the cure of squinting, it seems the most reasonable, in the first place, to endeavour to strengthen the weak eye by use, and by tying up the sound one. In this case, the distorted eye becomes properly directed to the object, and the strength of the impression is in some degree restored. When this has been persevered in for some time, and the person is allowed to look at any object with both eyes, the weak eye will perhaps be again distorted from the true axis; but, probably, with a painful effort and double vision, which shows some progress in the recurrence of the two eyes, and their proper sympathy, and that the impression on the weak eye is at least attended to. After this, it will be time enough, by Dr. Jurin's method, to endeavour to correct the squint:— "Place the child before you, and let him close the undistorted eye, and look at you with the other. When you find the axis of this eye fixed directly upon you, bid him endeavour to keep it in that situation, and open his other eye. You will now immediately see the distorted eye turn away from you towards his nose, and the axis of the other will be pointed at you. But with patience and repeated trials he will, by degrees, be able to keep his distorted eye fixed upon you, at least for some little time after the other is opened. And when you have brought

* Dr. Reid.

him to continue the axis of both eyes fixed upon you, as you stand directly before him, it will be time to change his posture, and to set him first a little to one side of you and then to the other, and so to practise the same thing; and when, in all these situations, he can perfectly and readily turn the axis of both eyes towards you, the cure is effected. An adult person may practise all this with a glass, without a director, though not so easily as with one. But the older he is the more patience is necessary. About twenty years ago, I attempted a cure, after this manner, upon a young gentleman about nine years of age, with promising hopes of success; but was interrupted by his falling ill of the small-pox, of which he died."

Dr. Jurin preferred this method to the use of tubes or shells with small holes in them, which have been recommended. But what appears to me the great difficulty, lies in the strength of the impression received upon the sound eye, which causing the impression of the weak eye to be entirely neglected, it is again thrown out of the line of direct vision. I conceive it, therefore, to be a necessary part of the experiment with tubes or shells, that the vision through the tube, applied to the sound eye, shall be so obscured as to have some accordance with the lesser sensibility of the weak eye, and then objects being seen equally with both eyes, a gradual accordance of the muscles may be produced. The conviction of the necessity of giving an equality to the strength of the sensation of both eyes must have struck M. de Buffon, since he says, in his Dissertation in the Academy of Sciences, that a plane glass should be applied to the weak eye and a convex one to the strong eye, so as to reduce the last to a state less capable of acting independently of the other.

But what is called a weakness, is very frequently, I am convinced, merely a short-sightedness in one eye: what the effect of this should be we may experience if we look to an object with both eyes, but with one of them through a concave or convex glass; if we are looking upon a book, there will be produced a confusion of the letters, but, by a little practice, the letters will become again distinct. By an attentive observation, we shall find that this is the consequence of attending solely to the impression received in the naked eye: nay, what is still more strange, we can attend, in this experiment, to the impression upon the point of the axis of one eye and to the general impression of both. If, while looking upon the letters of a large page, I move the convex glass of a small degree of power sideway before my right eye, the whole letters of the page seem to move, leaving distinct and stationary a circular spot containing a word or two. Here, by no effort, while I

look with both eyes, can I lose the steady and distinct sight of these few words, because their image is received upon the more sensible central point of the retina of my left eye: but all the other part of the sphere of vision I can see alternately, dimmed or distinct, as I choose to attend to the less powerful impression of the right eye, or the natural sensation of the left. We see, by this experiment, how easy it is to neglect the impression of one eye, if it be no stronger than that of the other, (and of course more easily if it be weaker,) and how impossible it is to neglect the more vivid impression.

From such a radical defect in the vision, as the humours of one eye having a different focus from the other, and consequently an indistinctness of vision produced from two images of different sizes intermingling their colours, children seem very frequently to be made to squint; and I have known adults, with a degree of the same inequality in the eyes, kept from squinting only by a particular attention to the direction of their eyes. M. de Buffon, in his Dissertation already quoted, after affirming what has been already delivered, viz. that no one squints with both eyes at once, says, he has observed three instances in which the eyes, according to circumstances, were alternately distorted from the object. This he accounts for by finding that, with one eye, the letters of a book could be seen at the distance of two or three feet, and not nearer than fifteen inches; while, with the other, the letters could be distinguished at the distance of from four to fifteen inches only. Consequently, when looking to distant objects, the image being more distinct with the long-sighted eye, the other was turned from the object; but when objects at a small distance were seen, the image in the far-sighted eye being imperfect, it is turned from the axis, that it may not interfere with the stronger image of the other eye, which is now directed to the object.

A frequent effect of the weakness left by long fevers in children, is a squint which gradually goes off as the strength is restored. It is observed, also, that squinting and double vision are, in some fevers, a concomitant with delirium and phrenitis. This symptom proceeds, in all likelihood, from an unequal tension of the muscles of the eyeball. The double vision is the effect of discordance in the action of the muscles.

CHAP. XII.

OF THE EYELIDS, OF THEIR GLANDS, AND OF THE COURSE OF THE TEARS.

Having completed the description of the eye, as the organ of vision, we have now to attend to its connections, its adventitious membranes, the glands of the eyelids, and the course of the tears. It is plainly necessary that the eye should not be loose in the socket; but that, in its rolling motion, it should still be attached; and that, although the delicate anterior surface must be exposed, the internal parts of the socket should be defended from the intrusion of extraneous bodies. This is accomplished by the tunica conjunctiva.

The tunica conjunctiva, or adnata, is the inflection of the common skin of the eyelids. It goes a little back into the orbit, and is again reflected, so as to come forward and cover the forepart of the eyeball. Here it is pellucid, and the white coat of the eye shines through it. It covers the cornea also; and here it is perfectly transparent; loses its character of vascularity, as the conjunctiva; and is assimilated to the nature of the cornea. As this coat is a continuation of the common integuments, it is, like them, vascular, and liable to inflammation. The tunica conjunctiva, is the common seat of ophthalmia. In the commencing inflammation, we see the vessels turgid or blood-shot; by and bye, they elongate towards the surface of the cornea; the patient complains of dimness; the dimness becomes apparent to the surgeon; spots of opacity then form in the cornea; and the vessels of the conjunctiva now take a course over the turbid surface of the cornea. In this stage of the inflammation, by cutting the turgid vessels of the conjunctiva, we interrupt the source of blood for a time, and procure a small evacuation; but these vessels soon coalesce again, and the flow of blood is renewed.

Eyelids.—Birds which mount into the higher and clearer regions of the atmosphere have a third eyelid, which is drawn across the surface of the eye. The eagle, which mounts the highest, and the owl, which is most sensible to the impression of light, possess this second guard to the eye. The membrane is drawn across the eye by a particular muscle; it is called membrana nictitans.

The TUNICA ALBUGINEA is the thin tendinous coat formed by the insertion of the recti muscles, which expand over the anterior part of the eye. I would admit this into the enumeration of the coats of the eye, merely to prevent confusion of names, and to make intelligible the descriptions of some of the older writers. It is not properly a coat. Where the conjunctiva covers the anterior part of the eye, the white sclerotic coat is seen under it; and in consequence of this, the tunica conjunctiva is sometimes called albuginea.

A very material part of the structure of the eye still remains to be described; an apparatus by which the surface of the eye is preserved from injury, kept moist and perfectly transparent.

The EYELIDS are composed of the common integuments, with this difference only, that they have a cartilaginous margin to give them shape, and muscular fibres, in the duplicature of their membrane, to give them motion. A small semilunar cartilage, which lies like a hoop in their edge, keeps them of a regular figure, and so as to close neatly over the eye. This cartilage having a triangular edge, and the base of the angle forming the flat surface of the margin of the eyelid, they meet with the most perfect accuracy. Either end of this hoop-like cartilage is connected with the periosteum at the corners of the eye, so as to move with its fellow as upon a hinge. This cartilage of the eyelid is called TARSUS.

The upper eyelid only, is moved for the admission of light to the eye; it is raised by the levator palpebræ muscle. But the eyelids are shut again by the orbicularis palpebrarum, which acts on both eyelids, and sometimes with such power, as to squeeze the eyeball even to a painful degree.

The MEIBOMEAN GLANDS.—These are very elegant little glands which lie under the inner membrane of the eyelids. About twenty or thirty ducts of these glands open upon the tarsus of each eyelid. These ducts run up under the vascular membrane of the inside of the eyelids, and minute glandular folicules, to the amount of about twenty, are, as it were, attached to each of these ducts. These glands exude a white sebaceous matter, which defends the edge of the eyelid from the acrid tears, and closes them more accurately by its unctuosity. The vascularity of the inner surface of the eyelid is subservient to these glands; for the vessels forming their ramifications round the little glands, secrete the sebaceous matter into them. This, then, is the seat of the ophthalmia tarsi; and following this inflammation, the edges of the eyelids, and the mouths of the ducts, are sometimes eroded with little ulcers: These ducts are the seat of the stye. This is an inflammation,

and closing up of the mouth of one of the ducts, which then swells up into a little hard granule in the edge of the eyelid, accompanied with inflammation of its cyst or surrounding membrane.

OF THE SECRETION AND COURSE OF THE TEARS.

The lachrymal gland is seated in the upper and outer part of the orbit, and behind the superciliary ridge of the frontal bone. It is of a flattened form, and is depressed into a hollow of the bone. Several ducts from this gland open upon the inner surface of the upper eyelid. By the reflection of the membrana conjunctiva from the eyelid over the surface of the eyeball, dust and motes are prevented from getting behind the eyeball; and when they have got under the eyelids, the extreme sensibility of the tunica conjunctiva excites the lachrymal gland, and the orbicular muscle of the eyelids, (which, by its pressure, accelerates the flow of the tears,) and the dust or motes are washed out. The puncture for re-absorbing the tears and conveying them into the nose, being at the inner angle or canthus of the eyelids, we see the intention of the ducts of the lachrymal gland opening on the inside of the upper eyelid towards the outer angle: for, by this means, the tears are spread over all the surface of the eyeball, by the motion of the eyelids, before they decline into the puncta. But the tears do not flow only when the gland is excited by motes; their secretion is perpetual, and, together with the motion of the eyelids, they perpetually moisten the surface of the eyeball. Even during sleep they flow continually; and here we may admire a provision for their conveyance towards the inner canthus, in the inclination of the tarsus to each other; for the eyelids meet only on the outer edge of the broad surface formed by the tarsus, the consequence of which is, that a kind of gutter is formed in the angle by the inner edges of the tarsus not meeting, which leads the tears from the ducts of the lachrymal gland towards the puncta lachrymalia.

The puncta lachrymalia are the mouths of two ducts which form the beginning of a canal for drawing off the tears from the eye into the nose. These puncta are placed at the inner canthus of the eye, and on the termination of the tarsus of the upper and under eyelid: they are surrounded by a rigid substance; and their patent mouths absorb by capillary attraction. They lead the tears into the lachrymal sac, and thence the tears pass into the nose.

The caruncula lachrymalis is that little granulating-like body which lies in the inner angle formed by the two eyelids.

Very small hairs are seen to sprout from it, and some small sebaceous folicles open upon its surface. Connected with the caruncula lachrymalis is the MEMBRANA OF VALVULA SEMILUNARIS. This is a vascular membrane which is drawn from under the caruncula lachrymalis by the direction of the eye outward, so as then to appear like a web spread over the white of the eye near the inner canthus. By directing the eye towards the nose, this membrane is again accumulated about the caruncula. This, then, is a very particular mechanism, not as is generally described, for applying the tears to the puncta lachrymalia, but for accumulating and throwing out the motes and dust from the eye, and for guarding the puncta from the absorption of such little particles as might irritate or obstruct them.

In birds, the valvula semilunaris is drawn, by a muscle and small tendon inserted into it, quite across the eye, so as to act like a third eyelid; it is in them called membrana nictitans.

The LACHRYMAL SAC and DUCT lie in the os unguis or lachrymale. The sacculus is a bag of an oblong or oval figure; it is sunk into the fossa of the os unguis, and defended by the frontal process of the superior maxillary bone; and it is covered by the ligamentous connection of the orbicularis muscle. This sac is the dilated upper end of the nasal duct; and into it the two canaliculi lachrymales (the extremities of which are the puncta,) open as distinct tubes.*

Two coats are described as covering the lachrymal sac; a nervous, white, external coat; and a vascular, pulpy, pituitary membrane. This sac, diminishing towards the lower part, and being received into the complete canal of the bone, becomes the nasal duct. Taking a course downward and backward, it opens into the nose under the inferior spongy bone. The lachrymal sac and duct are by some conceived to be muscular, so as to enable them to convey the tears into the nose; or it may be conceived, that they act like a syphon, the duct reaching down into the nose acting like the long leg of the syphon, and drawing the tears in at the openings of the puncta. Birds have a copious secretion of tears, which is necessary to them, from the rapid course through the air elevating the evaporation of the tears.

Fishes have no lachrymal gland: the fluid they swim in renders this secretion unnecessary. But I think it would appear, that the connections of the orbicularis muscle over the sac is of a nature to accelerate the passage of the tears, and even perfectly to compress the sac. The lachrymal sac and duct are

* Dr. Monro.

very frequently diseased and obstructed. For example, after small-pox, syphilis, or in scrofulous constitutions, the inner membrane of the sac being of the nature of the pituitary membrane of the nose, inflames, swells, and adheres. The consequences of this are, first, a swelling of the lachrymal sac in the inner angle of the eye, and a watery or weeping eye; upon pressing the tumour, the tears, mixed with mucus, are forced back through the puncta; by and bye the sac imflames and suppurates; matter is discharged by pressure of the sac: and, lastly, it is eroded and burst out, discharging the tears and matter on the cheek. This is the complete character of the fistula lachrymalis. While the sac bursts outwardly, it often does further mischief within, by making carious the thin lamina of bone in which it lies. The theory of the ancients, with regard to this disease, was that the disease was proceeding from the caries of the os-unguis, and they perforated with the actual cautery, until the patients smelt it in the nose! as much with the intention of remedying the caries as to give passage to the tears. But it is not the bone which is the obstruction to the perfect cure of this disease by operation, but the membranes, which close again after the most ingenious attempts to preserve the passage. The vis medicatrix, in this instance, seems not to be so well aware of her interest as some physiologists would inculcate. She is, here, ever at variance with the artifice of the surgeon.

BOOK II.

OF THE EAR.

CHAP. I.

OF THE SOUND, AND OF THE EAR IN GENERAL.

THE ear is that organ by which we are made susceptible of the impression of sound.

Sound is the effect of impression on the auditory nerve, by which corresponding change is produced in the brain; or we say sound is a vibratory motion of bodies depending upon their elasticity or tension. It may be produced by the vibration and motion of the air, but not without the intervention of solids. The human voice, for example, does not depend merely on the percussion of the air, but on that vibration, as combined with the tension and consequent vibration of the glottis, excited by the current of air; which, again, is modified by the mouth. The science of sound as producing melody and harmony is a very interesting and curious one, for by the succession of sounds or notes, and their consonance, there is a language for which words are no substitute.

There is no body impervious to sound, or, in other words, incapable of transmitting the vibration. That sound is communicated through the medium of the air, we know from the circumstance, that a bell, when struck in a vacuum, gives out no sound: and again, from this, that the condensed state of the atmosphere affords an easier communication of sound, and conveys it to a greater distance. The velocity of the impression transmitted by the common air is computed at 1130 feet in a second; and sound, when obstructed in its direct motion, is reflected with a velocity equal to that with which it strikes the solid body by which its progress is interrupted.

That water conveys the vibrations producing sound, has been proved by experiment. It was once the saying of natu-

ralists, that to suppose fishes to have the organ of hearing, would be to conceive that an organ were bestowed upon them without a possibility of its being of use. But we are assured of the fact, that, on the tinkling of a bell, fishes come to be fed;* and it was the custom for the fishermen on the coast of Brittany, to force the fish into their nets by the beating of drums,† as our islanders are at present accustomed to do when the larger fish get entangled amongst the rocks. We are told, that in China, they use a gong for the same purpose. These facts were once of importance, though more accurate observation has now made them superfluous. The Abbe Nollet took much pains to decide the question, whether water was a medium for sound. After considerable preparation, and acquiring a dexterous management of himself in the water, (for which he takes great merit to himself,) he found that he could hear under water the sound of the human voice, and even distinguish conversation and music. The human ear being an organ imperfectly adapted to this medium of sound, these experiments do not inform us of the relative powers of air and water in the transmission of sound. But another experiment of the Abbe Nollet proves, what indeed to me is sufficiently evident, from the structure of the ear of fishes, viz. that the water transmits a much stronger vibration than the air. When he sunk under water and struck together two stones which he held in his hands, it gave a shock to his ear which was insupportable, and which was felt on all the surface of his body, like that sensation which is produced when a solid body held in the teeth is struck by another solid body.‡ He observed in other experiments, that the more sonorous the bodies struck were, the less vivid was the impression; by which it would appear, that water, though it conveys an impression more strongly to the ear, than the air, is not equally adapted to the resonance and variety of tone. Indeed, this is a natural consequence of the water, a fluid of greater density being in close contact with the sounding body, and suppressing its vibration. In these

* Boyle.

† M. l'Abbe Nollet, Acad. R. des Sciences. Naturalists were very incredulous of the effect said to be produced by music on lobsters. Some may be so still; but we may trust the following observation of Minasius, in his Dissertation. "*Su de timpanetti dell udito scoperti nel Granchio Paguro.*" "Propriis observationibus certior factus asserit obscura nocte, placidoque mari "quoties piscatores ardentibus saculis paguri in littore hærentis oculos lucis "fulgore perstringunt, ut stupido, et pene præstigiato animale potiantur, fi "forte rumor aliquis ingruit. Cancrum illico se e littore subducere recipe- "reque intra undas." See *Scarpa Disquisitiones Anatomicæ* de Auditu in In- "sectis, &c.

‡ These experiments were repeated by Dr. Monro. See his Book of Fishes.

facts we shall find the explanation of some peculiarities in the structure of the ears of fishes.

Thus, we see, that the vibration of a solid body is continued through the air, and through water, until reaching the organ of hearing, it produces the sensation of sound. Sound, it will be evident, is also communicated through solids. When we put the ear to one end of a log of wood of thirty feet in length, and strike upon the other, we are sensible of the impression ; and when a solid body applied to the bones of the head, or to the teeth, is struck, we are sensible of the noise ;* and this is felt even by those who are deaf to impressions conveyed through the air : indeed it is part in this way that we are to judge whether deafness may be cured by operation, as depending upon some injury of the mechanism of the organ, or whether it be an incurable affection of the nerve, or brain itself. If the sound be perceptible when conveyed through the teeth, or when a watch, for example, is pressed upon the bone behind the outer ear, we are assured that the internal organ is unaffected ; and upon inquiring farther into the case, we may find that the deafness proceeds from some disease of the outer tube of the ear, or of that tube which leads into the throat, and that it can be remedied.

CHAP. II.

GENERAL VIEW OF THE VARIETIES IN THE EARS OF ANIMALS.†

There is in the scale of animals a regular gradation in the perfection of the organ of hearing. But, in the human ear, we find united all the variety of apparatus for communicating the vibration to the internal organ, and along with this the most extensive distribution of nerves in the labyrinth, or inmost division of the ear, to receive that impression.

The ultimate cause of this more complex structure is the greater power with which man is endowed of receiving through the ear, various impressions of simple sounds : language, music, and various modifications of the sense, of which the lower animals are probably incapable.

* Perhaps we cannot call this sound.

† In the following short account of the comparative anatomy of the ear, although I have taken every assistance in my power from books, I have described the structure, in all the examples, from my own dissections and observation.

As in treating of the anatomy of the eye, we do not attempt to investigate the manner in which light acts upon the retina, in producing the sensation of colours, but endeavour merely to explain the structure of the eye; to show how the coats support and nourish the humours; how the humours are subservient to the concentration of the rays of light, and assist their impulse upon the retina: so, in the same manner, in explaining the structure of the ear, we need not investigate the philosophy of sound, nor the nature of those impressions which are made by it on the sensorium through the nerves; our views are limited to the structure of the ear—we have to observe the mechanism by which the strength of vibrations is increased and conveyed inward to the seat of the sense, and the manner in which the nerve is expanded to receive so delicate an impression.

The method of studying this subject, which is at once the most instructive and the most amusing, is to trace the various gradations in the perfection of the organ through the several classes of animals. It is chiefly comparing the structure of the viscera, and the organs of sense in animals and in man, that comparative anatomy is useful in elucidating the animal economy. For example, in the stigmata and air-vessels of insects and worms; in the gills of fishes; in the simple cellular structure of the lungs of amphibiæ; in the more complicated structure of the lungs of birds; we observe one essential requisite, through the whole gradation, viz. the exposure of the circulating fluids to the action of the air. And in this variety of confirmation, we see the same effect so modified as to correspond with the habits and necessities of the several classes of animals. In the same manner, with regard to the circulating system, we are taught the explanation of the double heart in the human body, by tracing the variety of structure through the several classes of animals; from the single tube circulating the fluids of insects, the simple ventricle of fishes and reptiles, the double auricle and perforated ventricle of amphibiæ, up to the perfect heart of the warm-blooded animal. The organs of generation, and the economy of the fœtus in utero, is, in the same degree, capable of illustration from comparative anatomy. But most especially, in the structure of the ear, is there much scope for this kind of investigation. We find such varieties in the ear of reptiles, fishes, birds, and quadrupeds, as lead us, by gradual steps, from the simpler to the more complex structure.

The simplest form of the organ of hearing is that in which we find a little sac of fluid, and on the inside of the sac the pulp of a nerve expanded. If an animal having such an organ,

breathe the air, a membrane closes this sacculus on the fore-part; and, by means of this membrane, the vibrations of the air are communicated to the expansion of the nerve through the fluid of the sac. But if the animal inhabits the water only, it has no such membrane to receive the impression; the organ is incased in bone or cartilage, and instead of the membrane, some small bone or hard concreted matter is found in contact with the pulp of the nerve. The sound, passing through the waters, is, in such case, conveyed to the organ, not by any particular opening, but through the bones of the head; and this concrete substance, partaking of the tremulous motion, communicates the sensation to the nerve.*

For example, in the CRAB and LOBSTER, we find a prominent bony papilla or shell, which is perforated, with a membrane extended across the perforation, and behind this membrane there is a fluid, in which the nerve is expanded, and which receives the impulse conveyed to the membrane. In the CUTTLE-FISH, again, there is no external opening; there is merely a little sac under the thick integuments; this sac has in it a small concretion or bone for receiving the vibration; which, in this animal, is conveyed by a more general impression upon the head than in those last mentioned; and the vibration of this loosely poised bone or concrete seems equal to the provision of the membrane which, in the crab, closes up the external opening in the perforated shell.

In FISHES, there is a considerable variety of structure. Those which remain perpetually under water, have not the outer membrane, nor any apparatus for strengthening the first-received undulations of sound. But such as lie basking on the surface of the water, and breathe through lungs, have an external opening—a canal leading to the membrane, and behind the membrane bones to convey the vibration to the internal parts, and these internal parts, the seat of the sense, are actually as perfect as in terrestrial animals.

In neither of the species of fishes, the cartilaginous nor spinous fishes, is there a proper external opening, as in animals breathing air. They receive the impulse from the water, upon the integuments and bones of the head; but within the head, and in the seat of the sense, they have a most beautiful apparatus for receiving and conveying those general vibrations to the expanded nerve. There is in every ear, adapted to hearing under water, a bone or concretion, placed so as to vaccilate

* It is conceived by some that the antennæ of insects conveys to them the vibration of bodies, and that they may be considered as an imperfect variety of this organ.

easily, and which is destined to agitate the fluid in which it is suspended with a stronger vibration than could be produced merely by a general impulse. Besides this provision in fishes, there is a very elegant structure for still further increasing the surface destined to receive the impulse, and for exposing to that impulse or vibration a larger proportion of the expanded nerve. It consists of three semicircular tubes, which penetrate widely within the bones of the head. They are filled with a fluid, and have in their extremities a division of the nerve which is moved or otherwise affected by the vibration of the fluids contained within the tubes.

There is a slight variety, however, in the ear of cartilaginous fishes. In the head of the SKATE, for example, there is under the skin, at the back of the head, a membrane extended across a pretty regular opening. This, however, is not considered as the opening of the ear; but a passage, like a mucous duct, which is beside it, has given occasion to a controversy between Professors Scarpa and Monro; and it may not be out of place to inquire into this disputed point.

We have seen that water conveys the sound of vibrating bodies with a shock almost intolerable to the ear, and with a particular and distinct sensation over the whole body. We see, also, that, in the greater number of fishes, there is confessedly no external opening, the whole organ is placed under the squamous bones of the head. Yet the cartilaginous fishes which are supposed to have an external ear, swim in the same element, and are in no essential point peculiar in their habits. And we should receive with caution the account of any peculiarity in the organ of hearing of one class of fishes, which is not common to all inhabiting the same fluid. Such animals as occasionally pass from the water into the air, must have a membrane capable of vibrating in the air; but even in them, it is expanded under the common integuments, and protected by them. Were it otherwise, when the creature plunged into the water, it would be assailed with that noise (confounding all regular sounds,) of which man is sensible when he plunges under water. It appears opposite to the general law of nature, to suppose any species of fish having that simple and more delicate membrane which is evidently intended to convey atmospheric sounds only, while, on the other hand, creatures living in the water alone, should have an organization fit to endure the stronger vibration of their denser fluid, and which would be useless and absurd in those existing in our atmosphere.

When we come to examine the ear of the skate, we find, that what Dr. Monro conceives to be the OUTWARD ear of the

fish,* is really, as represented by Dr. Scarpa, a mucous duct merely;† which does not lead into the sacculi of the vestibule and semicircular canals, as appeared to Dr. Monro, and that to suppose this would be to acknowledge the free access of air and water to the immediate seat of the organ, and to the soft pulp of the auditory nerve, a thing absurd in every view, impossible in nature, and very wide of the truth.‡ To me it appears, that this narrow duct cannot be considered as the external ear; because we find in the skate a proper membrane under the thin integuments, quite unconnected with the duct, for transmitting the sound; and, upon following this mucous duct, we find it taking a circuitous course, and filled with a strong gelatinous matter; it is every where narrow, and filled with a glutinous secretion. It has no membrane stretched across it, and bears no resemblance to the external ear of any other animal.

We may conclude, then, that fishes have no external opening like terrestrial animals; that, instead of this outward provision, they have the moveable bone within the organ. Although the cartilaginous fishes have a membrane extended over part of the organ, which, in the spinous fishes is completely surrounded with bone, it is not to be considered as capable of the tremulous motions of the membrana tympani of terrestrial animals, but may be considered as analogous to the membrana fenestræ ovalis: and, since it lies deep under the integuments, we have no reason to believe that sound is transmitted to the organ of hearing in fishes, any otherwise than through the general vibration of the head.

The organ of hearing in amphibious animals, demonstrates to us a difference in the manner in which the sensation is received; for they have both the outer membrane to receive the vibration of the air, and a mechanism of small bone to convey this motion into the seat of the sense; and they have, besides, within the ear itself, a chalky concretion; a provision plainly

* "In the upper and back part of the head of a skate, and in a large fish "weighing 150 pounds, at the distance nearly of one inch from the articula- "tion of the head with the first vertebra of the neck or atlas, two orifices, "capable of admitting small sized stocking wires at the distance of about an "inch and a quarter from each other, surrounded with a firm membranous "ring, may be observed. These are the beginnings of the Meatus Auditorii "Externi." Treatise on the Ear, p. 208.

† Dr. Scarpa, speaking of this opinion of Dr. Monro, says, "qua in re vehe- "menter sibi hallucinatus est, ostia nimirum ductuum mucosorum, ut manifes- "tum est, pro auris meatubus accipiens. Etenim omnino nullum est in car- "tiligineis piscibus ostium auditus extus adapertum, membranaque *fenestræ* "*ovalis* sub communi integumento recondita jacet et cooperta."

‡ "Quod et absurdum est et a rei veritate quam maxime alienum." Vid. *Anatomicæ Disquisitiones de auditu et olfactu, auctore* A. Scarpa.

intended for propagating the motion communicated through the water.

In serpents, birds, and quadrupeds, we shall hereafter trace the various gradations in the perfection of this organ. We shall find, that, as the animal rises in the scale, the cavities and tubes of the ear are extended and varied in their form. Now, I conceive that, while the multiplied forms of the tubes and sphericles of the internal ear afford a more expanded and susceptible surface for receiving impressions, the consonant forms of the parts enable them to receive a stronger vibration, and a more perfect and modified sound.

A cord of a musical instrument will vibrate when another in exact unison with it is struck. The vibration communicated to the air is such as is adapted to the tension of the symphonic cord; and no other percussion of the air, however violent, will cause it to sound. Again, the air passing through a tube of certain dimensions, will not communicate to it a motion, nor call forth its sound, while the air, passing in equal quantity through a tube of one degree of difference, will rise into a full note. What holds true in regard to the unison of cords, is also true of cylinders, or even of the walls of a passage or room, a certain note will cause the resonance of the passage or room, as a certain vibration will call forth the sound of the tube of an organ; because it is, in all these instances, necessary that the impulse be adapted to the position of the surfaces and their powers of reverberation.

These few facts illustrate what I mean, by saying, that the various forms of the internal ear of animals, as they advance in the scale, give additional powers to their organ. In the first example of the simple ear, where a bone vibrates on the expanded nerve, I should conceive that the sensations were in consequence of this simple percussion capable of little variety; but in animals where, besides this simpler mechanism there are semicircular canals, and more especially in those animals, which have still a further complication of the forms of the ear, certain sounds will be peculiarly felt in each of these several cavities and convolutions; and while the sensation is becoming more distinct, by the perfection of the organ, it admits, also, of a greater variety of sounds or notes: so that a certain state of vibration will affect the semicircular canals, (one or all of them,) and produce the sensation of sound, which would not at all affect the vibration of the simple lapillæ lying in their sac.

CHAP. III.

DESCRIPTION OF THE ORGAN OF HEARING IN PARTICULAR ANIMALS.

IN THE LOBSTER AND CRAB.

In these animals, the structure of the ear is very simple; but it appears to me that Professor Scarpa, in his description, has imagined the organ to be more simple than it is in nature.

In the LOBSTER, there projects from near the root of the great antenna, an osseous papilla of a peculiarly hard and friable nature. In the point of this papilla we observe a foramen, and a membrane stretched over it. This is the seat of the organ of hearing. It is described as containing a sac of a pellucid fluid, which adheres to the membrane, while the auditory nerve is expanded upon the lower surface of the sac. Now, the lobster, being an animal which can live on land as well as in water, Scarpa gives this as an instance of a structure calculated to receive the sensation of sound equally well from the water or from the atmosphere. But, from the figure I have given of the ear of this creature, it will not appear to be so exceedingly simple; while there is evidently a provision for the reception of the vibration communicated through the water, though it does not indeed strictly resemble that which is commonly found in the ears of fishes. There is suspended behind the sacculus, and in contact with the nerve, a small triangular bone, which when pulled away,* is found to hinge upon a delicate cartilage. This bone seems evidently intended, by its being thus suspended in the neighbourhood of the PULP OF THE AUDITORY NERVE, for impressing upon that nerve the vibration from the water. The lobster, then, has, like the amphibious animals, a double provision for receiving the communication of sound alternately from the water or from the air.†

The ear of the CRAB differs from that of the lobster in this, that, under the projection, there is a moveable case of bone, to which we see a small antenna attached. Within this is the organ of hearing; and there is here an internal provision for

* See fig. 2.

† From the mucous-like transparency of the nerve in the lobster, it is difficult to ascertain its exact relation to this bone.

the transmission of sound to the auditory nerve, which consists simply in a few circumgyrations of a pellucid and flexible cartilage: an inspissated fluid surrounds this gyrous cartilage, while the pale auditory nerve is expanded behind it.

Of the ear of fishes.—In the heads of fishes there is a cavity separated by a thin vascular membrane from that which contains the brain. Within this cavity there is a sacculus distended with a fluid, and containing a small bone;* on the inside of this bag, (which is called the sacculus lapillorum,) a great proportion of the auditory nerve is expanded. In the cartilaginous fibres, there are three lapilli† contained in their proper capsules, and surrounded with a gelatinous matter,‡ each of the lapilli having its appropriated division of the acoustic or auditory nerve distributed upon it in a beautiful net-work.

This cavity in the head of fishes, resembles the centre of the labyrinth in the human ear, and is called the vestibule. Within the vestibule there is a limpid fluid, intersected every where by a delicate and transparent cellular membrane; and the parts within the vestibule are supported in their place by this tissue, which is similar to that which supports the brain in fishes.

Besides this central part of the organ in fishes, there are departing from the vestibule three semicircular cartilaginous canals,§ within which, are extended membranous canals. These membranous tubes contain a fluid distinct from that contained in the common cavity of the vestibule, nor have they any communication with the sacculi, which contain the lapilli, although they are connected with them.‖ These cartilaginous canals are of a cylindrical form, and being as transparent as the fluid with which they are surrounded, are not readily distinguished in dissection. Each of the cartilaginous canals is dilated at one of its extremities into a little belly, which is called the ampulla.

The auditory nerve in cartilaginous fishes¶ is first divided into two fasciculi, which are again subdivided into lesser nerves. These go to the three sacculi lapillorum, and to the ampullulæ of the semicircular canals. Before the division of the nerve peculiar to the sacculus pierces it, and is finally distributed, it

* See plate, fig. 3.

† In many of the spinous and squamous fishes there is only one. In cartilaginous fishes these bodies are not like bone, but like soft chalk. In the spinous fishes, on the other hand, they are of the shape of the head of a spear, and hard like stone.

‡ The gelatinous matter is rather before the bones, and distending the little sacculi.

§ See plate 7. fig. 3. and fig. 4. D D D.

‖ So Professor Scarpa asserts, in contradiction to others.

¶ The fifth pair of nerves in fish answers to the seventh in man: has the same division into the *portio mollis* and *dura*.

forms a singular and intricate net-work of filaments. The branches to the ampullulæ are raised on a partition which is opposed to the mouth of the cylindrical part of the tube.

In the spinous fishes, the three semicircular canals unite in a common belly; but in cartilaginous fishes, the posterior semicircular canal is distant from the others.

In fishes, all the parts of the ear are filled with a matter of a gelatinous consistence, or viscid fluidity; and the whole sacculi and semicircular canals are surrounded with fluid. That jelly is the most susceptible of vibration, is evident when we fill a glass, and allow a body to fall into it; for then the delicate vibration is communicated to the finger on the outside of the glass; or by striking the glass, we may observe the tremulous motion of the jelly. The semicircular canals, it is evident, are well adapted to receive the extensive vibrations communicated through the bones of the head, and to convey them inward to the nerve expanded in the ampulla.

From the simpler to the more perfect aquatic animals, we may trace several links of the chain by which nature advances towards the perfect structure of the ear. We return now to observe, in the first example of terrestrial animals, the most simple state of that part of the organ which receives the sensation; but where the structure of the receiving organ is the most simple, the mechanism for receiving the vibration and conveying it to the internal ear is modified and adapted to the atmosphere.

OF THE EAR IN REPTILES AND AMPHIBIOUS ANIMALS.

In reptiles, which form the intermediate class of animals betwixt fishes and quadrupeds, the ear has also an intermediate structure; in some individuals of this class the ear resembles that of fishes, such as we have described; while, in others, it resembles more nearly the common structure of terrestrial animals.

In the salamandra aquatica, a variety of the lizard, there is a foramen ovale,* deep under the integuments. In this foramen there is a cartilage, in immediate contact with which there is a common sacculus lying in the cavity or vestibule; and in this little sac there is found a cretaceous matter; there are here, also, semicircular canals, with ampullulæ, and a common

* This is the appropriated appellation of the opening which leads from the outer cavity of the ear, or tympanum, into the seat of the proper organ where the nerve is expanded.

belly connecting them. In this animal, then, it is evident, the ear is similar in structure to that of the cartilaginous fishes.*

In the FROG, the outward apparatus is different, but the internal ear is simple.† Under the skin of the side of the head, a little behind the prominent eye, we find a large circular opening, which tends inward in a funnel-like form: and from the upper part of the circle of this meatus we find a small elastic bone or cartilage suspended. This bone is in contact with the common integuments of the head, which are stretched over the little cavity. This first bone is placed at a right angle with a second bone, and both are lodged in a proper tympanum.‡ This second bone swells out towards its inner extremity, and is accurately applied to the foramen ovale. The foramen ovale opens into a cavity which we must call the vestibule, and which, in this creature, is peculiarly large in proportion to its size. This vestibule contains a sac, upon which the nerve is expanded; it contains also a chalky soft concretion, which is of a beautiful whiteness, and of a regular figure when first seen, but has no solidity.§ The vestibule here, as in all other animals, being the immediate seat of the sense, is filled with fluid.

In SERPENTS, the mechanism external to the seat of the organ is less complete than in the frog. From the scales behind the articulation of the bone which keeps the lower jaw extended, a little column|| of bone stretches inward and forward. This bone has its inner extremity enlarged to an oval figure, and is inserted into the foramen ovale. This creature has no membrana tympani, nor does it appear to have so good a substitute as the frog: the outer extremity of the bone seems rather attached to the lower jaw by a cartilaginous appendage and small ligament.¶ Within the skull, serpents have the little sac, with the cretaceous matter and semicircular canals, united by a common belly.**

In the TURTLE, we find a proper tympanum, and by lifting the scaly integuments from the side of the head a little above the articulation of the lower jaw, we open this cavity.

* It is said by naturalists, that the salamander never has been heard to utter a cry; and as dumbness is in general coupled with deafness, it is natural to suppose it has no ears. This is to consider the organ as subservient to conversation!

† See plate, fig. 5 and 6.

‡ This tympanum being a cavity containing air, has communication with the mouth by a tube, which we shall afterwards find called eustachian tube. Several have erroneously described this animal as receiving sounds through the mouth.

§ See fig. 6. D.

|| Plate, fig. 7. B.

¶ See Scarpa, tab. v. fig. ix.

** Serpents are affected by music; and they will raise and twist themselves with every variety of lively motion to the pipe and tabor.

Through this cavity there extends a very long and slender bone, which, upon the outer extremity, is attached by a little elastic brush of fibres to the cartilaginous plate under the integuments, while the inner extremity is enlarged, so as to apply accurately to the foramen, which opens in the vestibule; and a passage also opens from the cavity of the tympanum into the fauces. In this animal, as in all which we have classed under the present division, the internal ear consists of a central cavity, or vestibule, which contains a sac with fluid, and cretaceous matter, and of three semicircular canals connected by a common belly. This common belly of the semicircular canals has no communication with the sacculus vestibuli, which contains the cretaceous matter, further than as it lies in contact with it, and as they both lie surrounded by a fluid; they equally receive the impression of the little bony column, the extremity of which vibrates in the foramen ovale.

There being enumerated forty or more varieties of the LACERTA OF LIZARD, many of these have very different habits. Some of them never pass into the water, but inhabit dry and dusty places. The lacerta agilis, or common green lizard, which is a native both of Europe and India, is nimble, and basks, during the hot weather, on the trunks of old trees and on dry banks; but on hearing a noise it retreats quickly to its hole. It has the skin over the tympanum extremely thin, and such as to answer precisely the office of the membrane of the tympanum. So all the varieties of reptiles which, in their habits and delicacy of hearing, resemble terrestrial animals, have either the membrane of the tympanum, or a skin so delicate as to produce the same effect; while those which inhabit the water have a rough integument, or a hard scale, drawn over the tympanum. Besides this, some have a small muscle attached to the bone, which runs across the tympanum; it is like the tensor tympani, and is another step towards the proper structure of the terrestrial ear.

OF THE EAR IN BIRDS.

COMPARING the internal ear of birds with that of those animals which we have already described, we find a very important addition. We find here the internal ear (or labyrinth, as we may now call it,) consisting of three divisions: the vestibule, or middle cavity; the semicircular canals; and the cochlea; which last is an additional part, and one which we have not in the class of animals already described. Leading

into these three cavities, there are two foramina; the FENESTRA ROTUNDA, and the FENESTRA OVALIS; and both these openings have a membrane stretched over them in the fresh state of the parts. The first, the fenestra ovalis, or foramen ovale, receives the ossiculus auditus, which is in birds like that which we have already described in reptiles.* This ossiculus connects the membrana tympani (which is here of a regular form) with the vestibule, and conveys the vibration of the atmosphere to it.

The semicircular canals are here also three in number, and are distinguished by the terms minor, major, and maximus; but as the major and minor coalesce at one of their extremities, and enter the vestibule together, the semicircular canals open into the vestibule by only five foramina in place of six. Each of the semicircular canals is dilated at one extremity into an elliptical form, while the other extremity is of the natural size of the diameter of the tube. These canals are formed of the hard shell of bone, and are surrounded with bone, having wider and more open cancelli.

In the dry state of the parts, we find a cord passing through the semicircular canals, which some have called the ZONULÆ NERVOSÆ. But these are the membranous canals, which are contained within the bony ones, dried and shrunk up. Within the bony cavities of the labyrinth, there is laid a pellucid membrane which contains a fluid, has the nerves expanded upon it, and is the true vestibule and semicircular canals; while the bony case, which we have described, is merely the mould of these and the support of their delicate texture.†

The COCHLEA, one of the three divisions of the labyrinth, is but imperfect in birds, when compared with that part of the organ in quadrupeds and in man. The cochlea in birds consists merely of two cylinders, formed of cartilage, which are united toward their further extremity. While the opposite extremities diverge, and while one of these cylinders opens into

* Mr. Home, in his lecture on the muscularity of the membrana tympani, (vid. Phil. Trans. A. 1800,) says, in birds this membrane has no tensor muscle to vary its adjustments, but is always kept tense by the pressure of the end of the slender bone. This is a very imperfect account of the mechanism of the tympanum in birds. There are two bones, or one small bone with a cartilage, which lies along the membrana tympani. This elastic cartilage has two little tendons attached to it. Even the slender bone which stretches from the cartilage to the foramen ovale, the inner extremity of which is enlarged to fill up that hole, seems to have a small tendon inserted into it; but whether this be a muscular or ligamentous connection, I am unable at present to say.

† I lately, by accident, drew out the sacculus vestibuli and semicircular canals from the bony part of the ear of a bird, and I found the membranous semicircular canal to consist apparently of the same pellucid elastic matter with those of fishes.

the vestibule, the other opens outward into the cavity of the tympanum.*

That which more than any other circumstance distinguishes the organ of birds from that of animals inhabiting the waters, is the want of the bone or stony concretion in the sacculus vestibuli.

CHAP. IV.

OF THE HUMAN EAR.

THE anatomy of the human ear will naturally be considered under three heads: the external ear; the tympanum; and the labyrinth. The OUTWARD EAR requires no definition. From the outward ear there is a cartilaginous tube, which leads into the tympanum. The TYMPANUM is the cavity within which is placed that mechanism of bones and muscles which increases the strength of the vibration, and conveys it inwards to the labyrinth. The LABYRINTH is the general name of those intricate canals which contain the expanded nerve, and the immediate seat of the organ.

SECTION I.

OF THE EXTERNAL EAR.

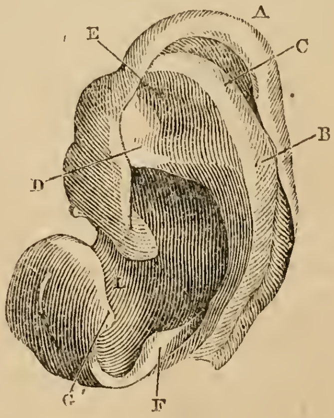
THE EXTERNAL EAR is formed of an elastic cartilage, covered with very thin integuments. The apparently irregular surfaces of the outer ear will be found, upon examination, to be so formed that the sinuosities lead gradually into each other, and finally terminate in the concha or immediate opening of

* We find Mr. Home saying that the cochlea is neither absolutely necessary to fit the organ to be impressed by sounds communicated through the air, nor to render it what is termed a musical ear; and that this is sufficiently proved by that part being wanting in birds, whose organ is particularly adapted to inarticulate sounds. That the cochlea is not necessary to the communication of sound through the atmosphere, we have seen from the examination of the ear of the reptiles. But since we see that it forms part of the labyrinth in birds, we may be led to doubt Mr. Home's conclusion.

the tube of the ear. By the constant motion of the external ear of quadrupeds, we see its importance to them both in collecting sound, and in judging of its direction. In most men, the motion of the ear is lost, but some men still retain it; and this is very remarkable, that when the more internal mechanism of the ear is injured, and ceases to strengthen the sound before it conveys it inwards to the labyrinth, the external ear resumes the office to which it was originally adapted, and by a degree of motion and erection, assists the hearing. In Europeans, the outward ear is in a great degree flattened to the head by the dress; but in eastern nations, and in ancient statues, we see the ears stand prominent, and bear a part in the symmetry and expression of the whole head. The muscles moving the cartilages, besides being intended to give motion, appear to have a more essential use in giving a due tension to the outward ear. These cartilages are surrounded with their peculiar pericondrium; but as to their vessels and nerves, it seems very superfluous to give a minute description of them here.

When the cartilages are dissected they appear thus:

Fig. 18.



A. The HELIX. It is the outer margin, the edge of which is turned over, and forms the cavitas innominata.

B C D. The ANTIHELIX. It is very prominent; of a triangular shape; and within the outer rim or margin.

E. The SCAPHA, which is a depression or cavity on the anterior part of the antihelix.

F. The ANTITRAGUS.

G. The TRAGUS. These are the two prominent points which

approach each other, and form the margin of the great cavity of the ear.

L. The CONCHA, or great cavity of the ear, and which is the trumpet-like opening of the meatus auditorius externus. The few pale coloured fibres which are found on the cartilages, are scarcely to be recognised as muscles.*

The LOBE of the ear, or that part which hangs down and is pierced for the ear-ring in women and savages, consists of skin and cellular substance merely.

The MEATUS AUDITORIUS EXTERNUS, is the tube which leads into the tympanum. This tube is partly bony and partly cartilaginous. The outer portion of the tube is cartilaginous, and about three quarters of an inch in length, and is divided by fissures. The internal part of the tube is formed in the bone, as we find upon turning to the description of the temporal bone.

GLANDS OF THE PASSAGE.—The cuticle, covering the inside of the tube, is very fine, and there project from it many small hairs which stand across the passage. Under this skin there is a set of small glands which pour their secretion into the tube, and are called the GLANDULÆ CERUMENOSÆ.† These glands, secreting the wax of the ear, have their little ducts opening betwixt the roots of the hairs; and this secretion with the hairs which stand across the passage, guards the internal parts of the ear from insects. The whole passage, consisting of the canal of the temporal bone and the cartilaginous tube placed upon it, has an oblique direction. It first passes upward and forward, and then makes a slight curve to descend to the membrane of the tympanum.

This external tube of the ear, being of the nature of a secreting surface, and exposed to the air, is liable to inflammation. There follows a dryness of the passages, and then a more fluid secretion. If the inflammation of the tube should extend within the bones, then, like the affections of all parts surrounded with solid bone, the pain is extreme and the danger considerable: there is not only suppuration in the tympanum and destruction of the membrana tympani, but the disease may be still further communicated internally. Hildanus gives us an observation of the effects of a ball of glass dropt by accident into the ear, in which the inflammation was so extensive, and the pain so excruciating, that the whole side of the head and even the arms and leg of that side were affected, in consequence of the brain partaking of the inflammation. Such

* See Valsalva & Santorini.

† "Hæ figuram obtinent variam; major tamen harum pars vel ad ovalem, "vel ad sphæricam accedit colore tinguntur flavo abhumore in earum folliculis "contento qui ob assiduam fibrarum carnearum reticularium pressionem, per "cutis correspondentia foramina in meatus auditorii cavitatem transmittitur." Valsalva de aure humana, p. 10.

things as peas and cherry-stones and pins are very apt to be put into the ear by children; and awkward attempts to extract the foreign body, very often push it further in; and acrid fluids put into the ear to kill insects, have forced them deeper, with such an increase of pain as has thrown the patient into a condition little short of delirium. A defective or too profuse secretion from the glands of the tube will cause a degree of deafness: and sometimes the wax is so indurated as to cause a very obstinate deafness:*

In the fœtus, the concha and meatus externus are narrow, and there is secreted a thick white stuff, which defends the membrane of the tympanum from the contact of the waters of the amnios. This, after birth, falls out in pieces along with the secretion of the wax; but, in some instances, it has remained and become very hard. The deafness from birth, caused by this accident, is often thought to depend upon an organic defect, and so is neglected.

SECTION II.

OF THE TYMPANUM OR MIDDLE CAVITY OF THE EAR, AND ITS DISEASES.

THE ANATOMY OF THE TYMPANUM.

In the fœtus, the cavity of the tympanum is superficial, compared with that of the adult; for what forms a tube in the latter, is in the former merely a ring, which is attached to the squamous portion of the temporal bone:† upon this circular bone the membrane of the tympanum is extended.

The cavity of the tympanum is very irregular; intermediate betwixt the membrane which is extended across the bottom of the external tube and the labyrinth or internal ear. It contains no fluid, as the labyrinth does; but is really a cavity, having a communication with the external air through a tube which leads into the fauces. The tympanum communicates also

* See Valsalva, p. 10. "Talis surditalis a duodecim annis affligentis curatio." The older writers treat of the "Auditus læsio a sordibus aurium lapidescentibus." See *Bonetus* & Jul. *Cassertus Placantinus*, "*De auditus organo*," *lib.* 1. *cap.* 20 *p.* 90. There is also mention made of an adventitious membrane closing up the passage and stretched above the membrana tympani. This is produced by a foul secretion, and resembles that which stuffs up the passage in the fœtus. See Fabricius de Chirurg operat. cap. de aur. Chirurg. Veslingius Anat. cap. 16. See Experiments on the Solvents of the Ear-wax by Dr. Haygarth, Med. Obs. and Inquiries, vol. iv. p. 198. He gives the preference to warm water over every other solvent.

† See plate 8. fig. 3.

backwards with the cells of the mastoid process.* The inner extremity of the meatus externus forms a circle which is pretty regular, and upon which the membrane of the tympanum is extended. That part of the cavity of the tympanum which is opposite to the termination of the meatus externus, is very irregular. It has in it the foramen rotundum and the foramen ovale; and betwixt these, there is an irregular bony tuberosity called the tubercle, from which there stretch back some exceedingly small spiculæ of bone, which connect themselves with the margin of the irregular cavity of the mastoid process. On the opposite side of the cavity there is a small eminence, with a perforation in its centre, called the *Pyramid.*

The FORAMEN OVALE† is in the bottom of a deep sinus; it is not strictly of an oval form, but has its lower side straight, while the upper margin has the oval curve. This opening leads into the vestibule or central cavity of the labyrinth.

The FORAMEN ROTUNDUM is more irregular than the oval hole. It does not look directly forwad, like it, but enters on the side of an irregular projection: it does not lead into the vestibule, but into one of the scalæ of the cochlea. In the recent state of the parts, the periosteum covering the surface of the cavity of the tympanum, takes away much of its irregularity. Where the tympanum leads backward into the CELLULÆ MASTOIDEA, this periosteum is also continued.

The EUSTACHIAN TUBE‡ extends forward from the cavity of the tympanum, and opens behind the palate.§ In the dry bones, the Eustachian tube is more like an accidental fissure, than a regular passage, essential to the economy of the ear. It appears thus irregular in the bones from the tube being towards the back of the nose, composed of a moveable cartilage covered with a soft membrane; as the tube approaches the opening behind the palate, it widens into a trumpet shape; and the extremity of the tube is governed by muscular fibres. Within the cavity of the tympanum, on the upper part of the Eustachian tube, there is a small canal, giving origin to the laxator tympani. This canal has been called *the spoon-like cavity.*

There can be no doubt that the Eustachian tube is designed for admitting the free access of air into the cavity of the tympanum, that by preserving a due balance betwixt the atmosphere and the air contained within the ear, the motion of

* When Valsalva, in a case of ulceration and caries on the mastoid process, threw in his injections, he found them flowing out by the mouth: viz. by the Eustachian tube through the tympanum. See Val. de aure humana, p. 89.

† Fenestra ovalis.

‡ Iter a palato ad aurem.

§ By some older writers, the Eustachian tube is called aqueduct, because they conceived that humours were evacuated from the tympanum by this passage.

the membrane of the tympanum may be free. This, at least, we know, that, when the extremity of the Eustachian tube is closed, we suffer a temporary deafness, which can be accounted for only by the confined air wanting a due degree of elasticity to allow the vibration of the membrane of the tympanum. I conceive it to be necessary, that the air in the tympanum be changed occasionally, which is, perhaps, accomplished by some actions of the throat and fauces forcing a new body of air into the Eustachian tube. The extremity of the Eustachian tube, next to the throat, may be temporarily obstructed by the cynanche tonsillaris, which is frequently attended with pain, stretching from the throat to the ear; or it may be closed by inflammation and adhesion of its mouth, by adhesion of the soft palate to the back of the fauces, by polypus in the nose, reaching down into the fauces and compressing it.*

OF THE MEMBRANA TYMPANI.

The membrane of the tympanum is extended over the circular opening of the bottom of the meatus externus. It has a little of an oval shape, and lies over somewhat obliquely, so that its lower margin is further inward than the upper. Its use is, to convey the vibrations or oscillation of the atmosphere, collected by the outer ear, inwards to the chain of bones in the tympanum. Although this membrane be tense, it is not stretched uniformly like the parchment of a drum, but is drawn into a funnel-like shape by the adhesion of the long process of the malleus to its centre. It consists of two layers of membrane, and has, naturally, no perforation in it; and the experiments of air, and the smoke of tobacco sent from the mouth through the ear, succeed only in those who have had the membrane of the tympanum partially, ruptured or eroded by ulceration. This membrane is transparent; and when we look into the tube of the ear, and direct a strong light into it, we observe it to be of a shining tendinous appearance.

The inner lamina of the membrana tympani is very vascular. It has, indeed, been said to resemble the iris, both in its profusion of vessels, and in the manner of their distribution.† This is carrying the conceit of their analogy too far.

* The following case is from Valsalva:—"Quidam plebeius ulcus gerebat "supra uvulam in sinistra parte, quod quidam eam, quam invaserat, partem "exeserat atque abstuleret sic, ut ulceris cavitas cum extremo sinistræ tubæ "orificio communicaret. Igitur quoties homo mollem turundam remediis im- "butam in ulceris cavitatem intrudebat: toties illico sinistra aure evadebat "surdus, talisque permanebat toto ex tempore quo turunda in ulcere relinque- "batur," p. 90.

† See Mr. Home's lecture on the structure and use of the membrana tympani. Phil. Transact. Part I. 1800.

I have observed an artery of a very large size (compared with the surface to be supplied) running by the side of the long process or handle of the malleus. In this course, it is giving out small branches ; and when the trunk arrives at the extreme point of the long process of the malleus, it divides into two branches, the extreme subdivisions of which run towards the margin of the membrane. This artery is, nevertheless, too small to require us particularly to avoid it in the puncturing of the membrane for deafness, produced by obstruction of the eustachian tube.

The opinions regarding the muscularity of the membrane of the tympanum, shall be reserved until we have considered the whole mechanism of the parts in the tympanum.

OF THE CHAIN OF BONES IN THE TYMPANUM.

The vibrations of the membrane of the tympanum are transmitted to the foramen ovale by four moveable bones; the malleus, incus, os orbiculare, and stapes. These bones are named from their shape, and the names assist in conveying an idea of their form. They are so united by articulation and small ligaments, as to form an uninterrupted chain; and while they transmit the vibration, their mechanism is such, that they strengthen the impulse. They have also small muscles attached to them, by which it is probable the whole apparatus has a power of adapting the degree of tension to the force of the impulse communicated to the membrane of the tympanum. I conceive that they increase the power of the ear for receiving the weaker sounds, and are, at the same time, a guard to the internal parts, from such violent shocks as might injure the nerve.

How necessary it sometimes is to damp and suffocate, in some degree, piercing sounds, we must all be sensible ; and in those who are habitually exposed to the sudden eruption of sound, the susceptibility of the nerve is injured, and they become very deaf. We have, in a late publication, an example of this in blacksmiths, in whom, it is common to find a degree of deafness ; and we find old artillery-men quite deaf, from the long practice of their profession.

The MALLEUS* receives its name from a resemblance to a hammer or mallet; it is, in some degree, like a bludgeon; the great head stands obliquely off from the body of the bone (if such it may be called) like the head of the thigh-bone.

* See plate 9. fig. 1. A.

Anatomists can scarcely be blamed, if, in describing the processes of this bone, they forget the body. I should consider that part as the body of the bone which stretches down from the circular margin of the tympanum, and is attached to the membrane, or what we should consider as the handle of the mallet. This part of the bone stands at an angle with the head and neck; tapers towards the extremity, and is a little curved down towards the membrane. From the larger end of the body of the bone there stands out an acute process; and from the neck attaching the bulbous head to the body of the bone, there stands out a very slender process, which is often broken off. The great head of the bone does not form a regular ball to be socketed in the body of the incus; there are irregularities in the contiguous surfaces of both the bones.

The INCUS* is the second bone of the chain; it receives its name from its resemblance to the blacksmith's anvil. It more resembles a tooth with two roots. On the surface of the body, it has a depression like the surface of the first molaris. Into this depression of the incus the head of the malleus is received. The shorter of the two processes, and the body of the bone, lie on the margin of the circular opening of the tympanum; and the acute point of this process is turned back into the opening of the mastoid cells. The long leg or process of the incus hangs down free into the tympanum,† and has attached to its point the os orbiculare.

The OS ORBICULARE is like a grain of sand, and is the smallest bone of the body: it is a medium of articulation betwixt the incus and stapes.

The STAPES‡ or stirrup is well named, for it has a very close resemblance to a stirrup-iron; the little head is articulated with the os orbiculare; the arch of the bone is exactly like that of the stirrup-iron, but elegantly grooved within, so as to give lightness to the bone. It has a membrane stretched across within. The base, answering to that part of the stirrup-iron upon which the foot rests, is not perforated, nor is it of a regular form, but is flat on one side, corresponding with the foramen ovale. It is this base of the bone which is attached to the membrane stretched over the foramen ovale.

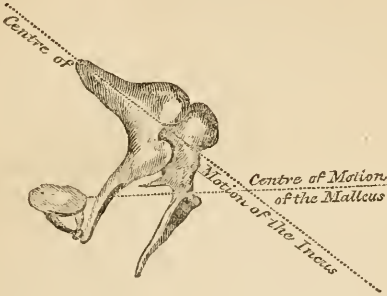
CONNECTION AND MOTION OF THESE BONES.

THE malleus hanging on that part which we have called the neck of the bone, has the long handle or body of the bone

* See plate 9. fig. 1. B. † See plate 4. fig. 1. D. ‡ See plate 9. fig. 1. C.

stretched down upon the membrane of the tympanum. It is, consequently, destined to receive the oscillations of that membrane.

The head of the malleus is so articulated with the incus, that the degree of motion communicated to that bone is much increased.



From this scheme, we see, that the head of the malleus is so articulated with the body of the incus, that the centre of motion of the incus is in a line drawn through the centre of its body, and, consequently, that the extremity of the long process, to which we see the os orbiculare and stapes attached, moves through a greater space than that which receives the impulse of the head of the malleus. Thus, a very small degree of motion communicated by the head of the malleus to the body of the incus, must be greatly increased in the extremity of the long process of the incus, and, consequently, this mechanism of the bones essentially assists in giving strength to the vibration which is transmitted inward to the seat of the nerve.

The os orbiculare stands simply as a link of communication betwixt the extremity of the incus and the upper part of the stapes, and its use is evidently to promote the accurate and perpendicular motion of this long lever of the incus upon the head of the stapes; for, if this bone had not been so placed, the motion of the long lever of the incus must have given an obliquity to the impulse upon the stapes. The base of the stapes almost completely fills up the foramen ovale. It is seated on a membrane which is stretched over the foramen.* The stapes, then, acts like a piston on a membrane of much

* Valsalva has the following observation, see page 24. "Olim namque in "cujusdam surdi cadavere surditatis causam in eo sitam inveni nempe quod "indicata membrana in substantiam osseam indurata, unum continuatum os "constituebat cum basi stapedis et margine fenestræ ovalis."

less circumference than that of the membrana tympani. From all which considerations, we may learn how much, and how strongly, the agitation of the air in the outer canal of the ear is increased, before it strikes upon the fluids of the labyrinth.

OF THE MUSCLES WITHIN THE TYMPANUM.*

THE laxator tympani runs in a fissure of the temporal bone on the outside of the eustachian tube, called the *spoon-like* cavity, and is inserted into the long process of the malleus. The TENSOR TYMPANI† runs also by the side of the Eustachian tube; it is inserted into the body of the malleus; it is a long and slender muscle. The external or superior‡ muscle of the malleus, which is denied by some anatomists to be of the nature of muscle, comes down from the upper part of the tympanum, and is fixed by a small tendon to the neck of the malleus.

The STAPEDIUS§ is the smallest muscle, and is attached to the smallest bone. It has a small round fleshy belly, taking its origin from the pyramid, and is inserted by a small round tendon into the head of the stapes.

As all these muscles are inserted either into the malleus or stapes, and not into the middle bone, it would appear that their operation is chiefly upon the membranes of the tympanum, and of the foramen ovale, through the medium of the bone immediately attached to them.

Mr. Home, in the Philosophical Transactions for 1800, asserts that the membrana tympani is muscular; that its fibres run from the circumference towards the centre; and that they are attached to the malleus.

But, what is the supposed use of this muscular membrane? Mr. Home says, it is principally by means of this muscle that accurate perceptions of sound are communicated to the internal organ; that it is by means of this muscle that the membrana tympani is enabled to vary its degree of tension, so as to receive the vibrations in the quick succession in which they are conveyed to it. But we have seen, that the tension and relaxation of the membrana tympani is already sufficiently provided for: "The malleus has three muscles by which it is moved; "one of them is called the tensor, from its pulling the malleus "inward and tightening the membrane of the tympanum; the "other two act in an opposite direction, and relax the mem-

* Musculus processus minimi mallei. Valsalva.
† Musculus processus majoris mallei.
‡ Musculus processus minoris. Valsalva.
§ This muscle is particularly strong in the horse, where it was first dicovered by Casserius.

"brane."* We should naturally suppose this to be sufficient; but according to Mr. Home, these muscles act only to bring the membrane into such a degree of tension, as to enable the minuter changes of the muscular membrane to have their full effect; and that the play of these muscles gives the perception of grave and acute tones.

But the more favourite idea of Mr. Home is, that, upon the accurate adjustment of the membrana tympani, the difference between a musical ear, and one which is too imperfect to distinguish the different notes in music, depends; that this judgment or taste is owing to the greater or less degree of nicety with which the muscles of the malleus render the muscular membrane capable of being truly adjusted; if the tension be perfect, all the vibrations produced by the action of the radiated muscle will be equally correct, and the ear truly musical.

Mr. Home proceeds upon the idea, that the membrane of the tympanum is like a musical instrument, or, as he expresses himself, like a monichord; but he is fundamentally wrong in supposing, that it requires a more delicate organ to be perceptible of musical tones than of articulate sounds or language.

In the first place, we may require an explanation of the use of that muscle which is inserted into the stapes. This stapedius muscle would seem to have the same use, and to affect that bone in the same manner, in which the muscles of the malleus affect it. Surely Mr. Home will not go so far as to say, that the membrana fenestræ ovalis is also muscular. It may be further worthy of attention, in considering this subject, that whatever affects the membrane of the tympanum, affects also the membrane of the vestibule; that, if the one be relaxed, the other is rendered tense, from the close connection that exists between them through the chain of bones.

In the paper already quoted, the following case is given, as illustrating the manner in which the loss of the natural action of the muscles affects the ear, in regard to its capacity for music. A gentleman, thirty-three years of age, who possessed a very correct ear, so as to be capable of singing in concert, though he had never learned music, was suddenly seized with a giddiness in the head, and a slight degree of numbness in the right side and arm. These feelings went off in a few hours, but on the third day returned; and for several weeks he had returns of the same sensations. It was soon discovered that he had lost his musical ear; he could neither sing a note in tune, nor in the smallest degree perceive harmony in the performance of others. For some time, he himself thought he had become a little deaf, but his medical attendant was not

* Mr. Home's Lecture.

sensible of this in conversation. Upon going into the country, he derived great benefit from exercise and sea-bathing.

In this case, continues Mr. Home, there appeared to be some affection of the brain, which had diminished the action of the tensor muscles of the membrana tympani, through the medium of the nerve which regulates their actions; this gradually went off, and they recovered their action.

Another case is given of a young lady who was seized with a phrensy which lasted several years, when, from being without a musical ear, she came to sing with tolerable correctness, to the astonishment of her friends.

Now, to me, the symptoms of both cases argue an affection of the brain and of the nerves. It is more probable that the delicate auditory nerve should be affected in such a disease, than that the portio dura should alone be affected.

We now proceed to put the incorrectness of this reasoning concerning the muscular power of the membrane of the tympanum, in a more particular point of view, leaving to Mr. Home's paper only the merit of ingenuity. Mr. Cooper was led to pay particular attention to the action of the membrane of the tympanum, from being consulted in a case where the membrane was lost with little injury to the function of the organ.* He found, that, instead of the total annihilation of the powers of the organ, the gentleman was capable of hearing whatever was said in company, although the membrane of both ears was destroyed. He could even hear better in the ear in which no traces of the membrane remained. This gentleman was only in a small degree deaf from the loss of the

* Case. This gentleman had been attacked, at the age of ten years, with an inflammation and suppuration in his left ear, which continued discharging matter for several weeks: in the space of about twelve months after the first attack, symptoms of a similar kind took place in the right ear, from which matter issued for a considerable time. The discharge, in each instance, was thin, and extremely offensive to the smell; and in the matter, bones, or pieces of bones, were observable. The immediate consequence of these attacks was a total deafness, which continued for three months; the hearing then began to return; and, in about ten months from the last attack, was restored to the state in which it at present remains. Having filled his mouth with air, he closed the nostrils, and contracted the cheeks; the air thus compressed, was heard to rush through the meatus auditorius with a whistling noise, and the hair hanging from the temples became agitated by the current of air which issued from the ear. When a candle was applied, the flame was agitated in a similar manner.

Mr. Cooper then passed a probe into each ear, and he thought the membrane on the left side was entirely destroyed, since the probe struck against the petrous portion of the temporal bone. The space usually occupied by the membrana tympani was found to be an aperture without one trace of membrane remaining. On the right side, also, a probe could be passed into the cavity of the tympanum; but here, by conducting it along the sides of the meatus, some remains of the circumference of the membrane could be discovered, with a circular opening in the centre, about the fourth of an inch in diameter. See Trans. Roy. Soc. for 1800. Part. I. p. 151.

membrane; but his ear remained nicely susceptible of musical tones, "for he played well on the flute, and had frequently "borne a part in a concert; and he sung with much taste and perfectly in tune." This case puts aside, at once, that theory which supposes the musical ear to depend on the minute play of the muscles of the tympanum.

It appears, then, that the membrane of the tympanum may be destroyed, that the bones may be washed out by matter formed in the tympanum, and still the patient retain the use of the organ. But this is only while the stapes retains its place; for if this bone be also destroyed, the membrane of the foramen ovale will be destroyed, and the fluids of the labyrinth be allowed to flow out, or be otherwise lost. We see that, if the chain of bones, and only a part of the membrana tympani be left, still this shred of membrane, if it be not detached from the handle of the malleus, will vibrate in the air, and communicate those vibrations through the other bones to the vestibule. We see, also, that though the bones only remain, and though they be detached from the membrane of the tympanum, the sound will still be communicated. We see, that a rupture of the membrane will not destroy the organization so far as to prevent the hearing, unless there follow clots of blood or inflammation, suppuration, or fungus. When Mr. Cooper found that the membrana tympani could be torn without injuring the organ, he did not stop short in his investigation: but as he found, by daily experience, that obstruction of the eustachian tube caused deafness, he thought of puncturing the membrana tympani, as a cure for that kind of deafness. He expected, by this operation, to give elasticity to the confined air. Accordingly, by puncturing the membrane of the tympanum with a small trocar, he found, with much satisfaction, that the hearing was instantly restored.*

Valsalva made a good distinction, when he said, that the membrane of the tympanum was not absolutely necessary to hearing, but only to perfect hearing. We have, in this fact, the explanation of the following circumstance, amongst many others: "In naturali surditate a conformationis vitio inter tandum istud experimentum, (viz. an ossiculi et membrana "tympani aliquis sit usus auditum,) quod inopinato et feliciter "successit cuidam, qui intruso auri scalpio in aurem profundissime disrupit tympanum, fregitque ossicula et audivit."†

* I am only afraid that such punctures will not continue open, as in Valsalva's experiments they healed up very soon. But, when there is no other ingress and escape to the air in the tympanum, but through the punctured hole, it may tend to keep it open. See much of this in Morgagni, Epist. An. XII. The membrana tympani is very vascular, I have it red with injection. See Ruysch. fig. 9. tab. 9. Epist. An. VIII.

† Biolanus Encherid. Anat. lib. 4. c. 4. See also Bonetus de Aurium Affect. Observ. IV.

Willis also knew, that the destruction of the membrana tympani did not deprive the person of hearing. *Vid. de Anima Brutorum.*

§ 2. OF THE DISEASES OF THE TYMPANUM.

VALSALVA denied the existence of periosteum to these bones of the tympanum, while he allowed that they had minute vessels distributed on their surfaces: but these vessels he supposed to creep along the naked bone independently of any membrane. This, however, is contrary to all analogy.* These bones, as well as the cavity of the tympanum, are covered with a very fine membrane or periosteum, which after a minute injection, is seen covered with many small and distinct vessels, as well as with intermediate extravascular effusions of the injection, as happens in injecting in other membranes.

When the tympanum becomes diseased, there is fetid matter collected, the membrane of the tympanum suffers, and the small bones are sometimes discharged. In such a case, we have little farther to do than, by injections, to prevent the matter from accumulating. But, let us not confound this serious cause of deafness with the slighter suppurations in the outer passage of the tube: although such suppurations in the tube of the ear are apt, when neglected, to destroy the membrane of the drum or tympanum, and to spread disease to these internal parts.

Authors make a display of the diseases of the membrane of the tympanum under the titles relaxatio, tensio nimia, induratio, and diruptio tympani.† We have seen how little rupture of the membrane affects the hearing, and may thence conclude, that these fantastic imaginings about tension and relaxation of the membrane deserve little notice. The idea of relaxation of the membrane of the tympanum, I have no doubt, has arisen from the effect of cold and moist weather in injuring the hearing, but deafness from this cause is not produced by relaxation of the membrane of the tympanum, but by swelling of the mouth of the eustachian tube.‡

Induration of the membrane is less of an imaginary disease,

* See Ruysch. Epist. Anat. VIII. tab. 9.

† See Du Verney de Organo Auditus, p. 41.

‡ "Relaxatio fit ab humore superfluo qui membranam hanc humectat et "symptoma hoc communiter cum obstructione meatus ex tumore glandu- "larum conjunctum est, de qua jam supra dictum est: multum autem facit "ad difficultatem audiendi in personis quæ defluxionibus catarrhosis obnoxiæ "sunt et per eandem rationem austri nebulæ et aer pluvius auditum minuunt "ut experiri quotidie possumus." Du Verney loc. cit. p. 41.

since there are instances of the membrane becoming thickened by inflammation, or cartilaginous, or osseous. The membrana tympani has been found to adhere to the extremity of the incus.* Independently of the want of elasticity, which such an adhesion must produce, the mechanical effects, the vibration of the bones, is prevented, and a degree of deafness is inevitable.

Fungous or polypous excrescences from the glands in the outer passage of the ear, press back and destroy the membrane of the tympanum. In the cure of these by the knife, caustic, or ligature, there is much danger of injuring the membrane. Fungous tumours project from the membrane itself. A stroke upon the head will cause bleeding from the ear. This is often a sign of concussion of the brain; that is to say, a shock so severe as to rupture the membrane of the tympanum, will most probably injure the brain † After bleeding from the ear, sometimes suppuration follows;‡ and blood flowing thus from the membrane of the tympanum, or other part of the ear, runs back into the cavity of the tympanum, and, filling it with coagulum, causes deafness, by obstructing the free motion of the bones and membrane. Mr. Cooper, in a case of this kind, punctured the membrane, and after a discharge of blood which continued for ten days, the hearing was gradually restored. It is supposed by that gentleman, that the blood effused becomes, in some instances, organized, so as to obliterate the tympanum, causing permanent deafness.

The danger in suppuration and caries of the tympanum is, that the disease may penetrate backward into the mastoid cells and labyrinth, or into the brain itself; for inflammation and suppuration so confined amongst the deep recesses of the bone, must give great torture, and be apt to extend the mischief to the brain, or throw out matter on the inside of the cranium, the effect of which must be mortal. Such, I think, I have seen, to be nearly the effect of suppuration deep in the ear. In a man who had been deaf for many years, and who was killed by a fracture of the skull, I found the cells of the temporal bones filled with matter, and a thin greenish fluid lay betwixt the temporal bone and dura mater. I have since found the caries of the petrous bone from this cause fatal.

* See the London Philosophical Transactions for 1800, Part I. p. 5.

† When Valsalva found the ventricles of the brain full of blood, and blood also in the tympanum, he supposed that the blood in the latter was derived from the brain through certain foramina which he discovered. See p. 30.

‡ See Valsalva, p. 16.

Valsalva gives us a case of injury of the head, in which the patient was relieved while the discharge of pus by the ear was free; but he died when it was entirely suppressed.*

But, after such suppuration as we should naturally think must totally destroy so delicate an organization, we are sometimes agreeably surprised with a gradual recovery of the function. This is owing to the nerve accommodating itself or becoming sensible to a less forcible impression, and by the ear acquiring new properties. I already mentioned that the destruction of the mechanism of the tympanum arose sometimes from suppurations beginning in the outward ear; and we may suppose that the apparatus within the tympanum, when partially hurt, is sometimes capable of being, in some degree, replaced by a natural process; of which the following case from Valsalva is a remarkable proof.

" I lately examined the ears of a woman whose hearing had been much injured by an ulcer of the tympanum and caries of the small bone. I found the ear in which she was deaf without a membrana tympani, and the stapes only remaining of the bones, and a fibrous mass, like an excrescence, in the tympanum. But in the tympanum of the opposite ear, I found the membrana tympani almost entirely eroded; so that the malleus and incus were uncovered, and distinctly seen. I could even observe, that the long process of the incus, which should be articulated with the head of the stapes, was separated from it: but nature had curiously restored the eroded membrane. Thus, from the edge of the injured membrane, a new membrana tympani was obliquely stretched across the cavity of the tympanum, so as to exclude the malleus and incus from that cavity, but including the head of the stapes, as if nature, finding the separated bones no longer necessary, had attached the membrane to the head of the stapes."† We have already remarked, that, when the organ of one side is injured, we hear so much better with the other, that we attend only to the sensation conveyed by it, and neglect the duller sensation. The consequence of this is, that the bad ear becomes worse. It is much like that effect which takes place in eyes by squinting.

* Valsalva, p. 83. See also a case in Bonetus de Aurium Affect. Observ. I., and Gul. Ballonius Epid. et Ephem. lib. 2. p. 270. When the matter was suppressed, there came pain of the head, and weight, which yielded to no remedy; on dissection, there was found an abscess within the skull. In Bonetus loc. cit., a case is related, in which an ignorant surgeon compressed a fistulous ulcer in the ear, and so caused the death of the patient.

† See Valsalva de Aure Humana Tract. p. 79. In those deaf from birth it has been twice found that the *incus* was wanting. See *Bonetus de Aur. Affect. Observ.* IV.

SECTION III.

OF THE LABYRINTH.

The labyrinth is the internal ear: the proper seat of the sense of hearing. It consists of the vestibule or middle cavity; of the semicircular canals; and of the cochlea. It has its name from those cavities and tubes leading into each other in so intricate a manner, as to be followed out with much difficulty.

We understand that the cavities hitherto described in the human ear contain air, and communicate with the atmosphere: but, in the cavities we have now to describe, the nerve is expanded, and there is, in contact with it, not air, but an aqueous fluid. In treating of this division of our subject, we have, first, to attend to the forms of the cavities, as seen when sections are made in the dry bones next to the soft parts contained in those cavities; and, finally, to the distribution of the nerves. To give an idea of the exquisitely delicate and complex structure of the many canals, excavations, openings, fulci, and foveæ, of the bones; of the tubuli, sacculi, and partitions of the membranes; and, lastly, of the soft expansions of the nerves, without the assistance of plates, would be impossible. Albinus, in his academical annotations, begins very formally a chapter on the ear; but, after a few words, dismisses the subject, referring merely to his plates.

The VESTIBULE, or central cavity of the labyrinth, is of an oval form, and about a line and a half in diameter.* It has two remarkable pits or hollows in it, and has numerous foramina opening from it into the neighbouring cavities, besides lesser foramina for transmitting that portion of the nerve which is distributed on the sacs contained in it. One depression or fovea is in the back or lower part of the vestibule, another in the outer and superior part of it: the one is circular, the other semi-oval. Morgagni, and other anatomists, examining the dry bones, speculated on their use in reverberating the sound in the cavity; but we must not regard them in this unnatural state: on the contrary, they contain in the living subjects membranous sacculi filled with fluid, in which membranes the nerve is finally distributed. That foramen over which the stapes is placed, and which is called the foramen

* Du Verney Œuvres Anatomiques.

ovale, transmits the vibration into the vestibule. For the foramen ovale opens directly into the vestibule, and through the vestibule, only, does the vibration of the bones in the tympanum reach the other parts of the labyrinth.

Semicircular canals.—When we have cut into the vestibule, by taking away that portion of the os petrosum which is behind the meatus auditorius internus, we see five circular foramina: these are the openings of the semicircular canals. There are three semicircular canals; and they are distinguished by the terms, the superior or vertical, the posterior or oblique, and the exterior or horizontal. The one which, in this view, is nearest, is the opening common to the inner ends of the posterior and superior semicircular canals. When we pass a bristle into this common foramen, and direct it upward, it passes along the superior semicircular canal, and will be seen to descend from the upper part or roof, of the vestibule, almost perpendicularly on the foramen ovale, which is open, and immediately opposite. If, again, we pass a bristle into the foramen which is near the bottom of the cavity, (and which will be just upon the edge of the fracture that has laid open the vestibule, if not included in it,) it will come out by the opening common to the superior and posterior semicircular canal. It has passed, then, along the posterior canal. The two openings of the exterior or horizontal canal are upon the back part of the vestibule; and the canal itself takes a circle which brings its convexity to the confines of the mastoid cells. These canals are formed of a very hard brittle bone, their calibre is so small as not to admit the head of a common pin; they form somewhat more than a half circle; and of each of them, one of the extremities is enlarged like the ampullula of fishes. Valsalva imagined that the enlarged extremities of these tubes were trumpet-like, to concentrate and strengthen weak sounds. We shall find, on the contrary, that there is in the human ear, as in fishes, a particular expansion of the nerve in these extremities of the tube, opposed to the circulatory vibration of the fluids in the canals.

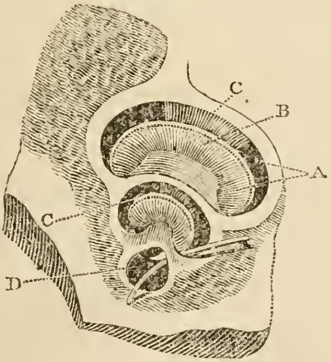
The cochlea.—The third division of the labyrinth is the cochlea. It is so named from its resemblance to the shell of a snail, or from the manner in which its spiral lamina turn round a centre like a hanging stair. It has been minutely, but not simply described; and, indeed, there can be nothing more difficult than to describe it in words.

When the os petrosum is cut from around the cochlea, it is seen to be of a pyramidal shape, and to consist of a scroll, making large circles at the base, and gradually lesser ones towards the apex. It is formed in the most anterior part of the

petrous bone, and has its apex turned a little downward and outward; and the base is opposed to the great cul de sac of the internal meatus auditorius.

The spiral tube of which the cochlea is composed, forms two turns and a half from the basis to the point; and it consists of the same hard and brittle matter with the semicircular canals. When the whole cochlea is cut perpendicularly in the dry state of the bones, and when the membranes have shrunk away or spoiled, the sides of the spiral canal appear like partitions, and are indeed, generally described as such. In consequence of the spiral tube of the cochlea having its sides cut perpendicularly, the cochlea appears as if divided into three circular compartments or successive stages; but there is really no such division; because the spiral turnings of the tube lead from the one into the other.

Fig. 19.
Cochlea.



A. Scalæ. B. Lamina Spiralis.
C. C. Modiolus. D. Infundibulum.

What gives particular intricacy to the structure of this part of the labyrinth, is the LAMINA SPIRALIS. This spiral partition runs in the spiral tube of the cochlea, so as to divide it in its whole length; and, in the fresh state of the parts, this lamina of bone is eked out by membrane, so as to form two perfectly distinct tubes. These tubes are the SCALÆ COCHLEÆ: they run into each other at the apex of the cochlea; but at the base, the one turns into the vestibule, and the other opens into the tympanum by the FORAMEN ROTUNDUM.

In the middle of the cochlea there runs down a pillar, which is the centre of the circumvolutions of the scalæ. It is called

the MODIOLUS. This pillar is of a spongy structure; and through it the nerves are transmitted to the lamina spiralis, and sides of the cochlea.

The modiolus opens towards the apex of the cochlea like a funnel: and when we take away the outward shell of the apex of the cochlea, which is called the CUPOLA, we look into this expansion of the upper part of the modiolus as into a funnel; it is therefore called the INFUNDIBULUM. The infundibulum is that part which, in a perpendicular section, we should call the upper partition.*

The scalæ or divisions of the spiral tube of the cochlea, have a communication at their smaller extremities in the infundibulum; and as, again, their larger extremities do not open into the same cavity, but one into the vestibule, and the other into the tympanum, the vibrating motion, which is communicated through the cochlea, must pass either from the tympanum into the foramen rotundum, circulate round the modiolus by the scala tympani, pass into the lesser extremity of the scala vestibuli in the infundibulum, and circulate through it towards the base of the cochlea, until it pass into the vestibule; or it must pass from the scala vestibuli into the scala tympani. The first is the opinion of Scarpa and others. But I trust it will afterwards appear, that the oscillations of sound are in the first place conveyed into the vestibule, and thence circulate round both the semicircular canals and cochlea.

In the dry bones, when we cut into the cochlea, there appears a spiral tube, as I have described; with a partition running along it, and, of course, taking the same spiral turns with it towards the apex. This is the bony part of the lamina spiralis; but, as the membrane which extends from its circular edge quite across the spiral tube of the cochlea, has shrunk and fallen away in the dry state of the parts, the lamina spiralis is like a hanging stair, and the scalæ are not divided into distinct passages. In this bare state of the shell of the cochlea, when we cut away the cupola or apex of the cochlea, and look down upon the infundibulum, we see the extreme point of the lamina spiralis rising in an acute hook-like point.

The modiolus or central pillar, and the lamina spiralis which encircles it, are of the most exquisite and delicate structure; for, through them the portion of the seventh nerve destined to the cochlea is conveyed. To say that the modiolus is formed of two central bones, is saying that there is no central column at all; or, that the modiolus is the cavity seen in the bottom of the meatus auditorius: and to affirm, at the same time, that

* That is supposing the cochlea to rest on its base.

the modiolus is a nucleus, axis, or central pillar, is a contradiction in terms.

When we break away the shell of the cochlea, and break off, also, the spiral lamina, we find the little funnel-like depression in the bottom of the meatus internus reaching but a little way up into the centre of the cochlea.—We find this depression of the meatus auditorius internus perforated with innumerable small holes; and these foramina are so placed as to trace a spiral line, because they give passage to the nerves going to the spiral lamina, and must take the form of the diminishing gyrations of the lamina spiralis. In the centre of these lesser foramina, which are seen in the bottom of the great foramen auditorium internum, there is a hole of comparatively a large size, which passes up through the middle of the pillar. The modiolus is formed of a loose, spongy texture, and resembles the turns of a cork-screw; and this spiral direction is a necessary consequence of the lamina spiralis, being a continuation of the spongy or cribriform texture of the modiolus.

Internal periosteum of the labyrinth.—We find that the vestibule, the semicircular canals, and cochlea, besides their soft contents, which we have yet to describe, have their proper periosteum, which, after a minute injection, appears vascular; and this, as it has appeared to me, is particularly the case with the last-mentioned division of the labyrinth. I see very considerable vessels distributed on the vestibule; particularly, I see their minute ramifications on the circular fovea, while very considerable branches are seen to course along the semicircular canals. In the cochlea, I see distinct branches of vessels rising from the root of the lamina spiralis, and arching on the scalæ, to the number of ten in the circle; and, after a more minute injection, I have found the osseous part of the lamina spiralis tinged red, and the membranous part of a deep scarlet.*

We have observed the meatus auditorius internus to be a large oval foramen in the posterior surface of the pars petrosa of the temporal bone. This tube transmits the seventh or auditory nerve. It is about five lines in diameter, but increases as it passes inward; and appears to terminate in two deep fovea, which are divided by an acute spine. But the auditory foramen only appears to terminate in these fovea, for they are each perforated by lesser holes, which lead into the three divisions of the labyrinth, whilst a larger one conveys a portion

* In a preparation before me, I see a considerable artery derived from the basilar artery, entering the meatus auditorius internus. From this trunk, I conceive that most of these arteries which I have described are derived.

of the nerve through the cavities of the temporal bone altogether, and out upon the side of the face. This larger foramen is in the upper part of the superior and lesser fovea. It first ascends to near the surface of the petrous part of the temporal bone,* and then descends and turns backward and takes a course round the tympanum above the foramen ovale; and close by the posterior semicircular canal. Its termination is the foramen stylo mastoideum.† Where this canal of the portio dura advances towards the surface of the pars petrosa, it is joined by a very small canal which extends from the videan hole on the forepart of the inclining face of the bone: again, after it has passed the tympanum, it is joined by a short canal which receives the corda tympani, after it has passed the tympanum.

The other foramen which is in the upper and lesser fovea of the meatus internus, is rather a cribriform plate, as it is a deep pit with many foramina in it. These lead into the vestibule, and form the MACULA CRIBROSA VESTIBULI.‡ In the inferior and larger fovea, we observe several dark spots, which, when more narrowly examined, are also distinguished to be cribriform plates, or collections of lesser foramina. We particularly observe that conical cavity which is perforated with many little pores for transmitting the nerve into the cochlea, and which we have already mentioned. From the form which these foramina take, this is named the TRACTUS SPIRALIS FORAMINOLOSUS. These foramina, after passing along the modiolus cochleæ, turn at right angles, and pass betwixt the plates of the lamina spiralis.

Besides the tractus spiralis foraminolosus the bottom of the larger fovea has many irregular foramina, which are like cancelli: for very delicate spiculæ of bone stand across some of them. There is a range of these foramina which stretches from the tractus spiralis. This may properly be called the TRACTUS CALTHRATUS RECTUS;§ they do not lead into the vestibule, but into the beginning of the lamina spiralis, where it divides the two scalæ cochleæ, and turns the orifice of one of them, (by a beautiful curve,) out into the tympanum.

Nearer to the ridge which divides the two foveæ of the meatus internus, there is a little pit which has also a cribriform plate (like that which is in the upper fovea, and is called macula cribrosa;) opposite to this point the inside of the vesti-

* In the fœtus, it becomes here superficial.
† This is the aqueduct of Fallopius.
‡ See Scarpa, Plate VII. fig. 1. m.
§ Tractus spiralis foraminulosi initium. Scarpa.

bule is rough and spongy : it transmits a portion of the nerve to the sacculus in the hemispherical sinus of the vestibule.*

OF THE SOFT PARTS CONTAINED IN THE LABYRINTH.

WITHIN the vestibule, semicircular canals and cochlea, there are soft membranes independent of the periosteum. These form sacculi and tubes which contain a fluid, and have the extreme branches of the portio mollis distributed among them. Betwixt the soft and organized sacculi and tubes and the periosteum of the osseus labyrinth, a watery fluid is exuded.

SACCULUS VESTIBULI. The hemispherical and semi-elliptical foveæ which we have described in the vestibule, contain, or at least receive partially, two sacculi. The Sacculus which is in the hemispherical cavity, receives the most convex part of the sacculus vestibuli. This sac is distended with a fluid, and is pellucid, and fills the greater part of the vestibule; for only a part of it is received into the fovea. It forms a complete sac, and has no communication with the other soft parts of the labyrinth, though lying in contact with the alveus communis, presently to be mentioned; and being surrounded with an aqueous fluid, it must receive the impressions or sound in common with them.

ALVEUS COMMUNIS DUCTUUM SEMICIRCULARUM.—This sacculus lies in the semi-elliptical fovea of the vestibule, or like the other sacculus, is in part received into it. This sacculus receives the extremities of the tubuli membranacei which lie in the semicircular canals ; it is a little bag common to them, and connecting them altogether, as in fishes : it is filled with fluid, and is so pellucid, as to be distinguished with much difficulty.† Upon pressing the common sac, or the ampullulæ of the semicircular canals, the fluids are seen to circulate along the membranous tubes of the canals. These two sacculi in the vestibule lie together, and firmly adhere, but do not communicate ; yet (as may be easily imagined) they cannot be separated without tearing the partition.

TUBULI MEMBRANACEI.—The tubuli membranacei are the semicircular tubes which pass along the osseous semicircular canals, and to which the latter are subservient, merely as supporting them. They are connected by means of the common alveus in the vestibule, and form a distinct division of the organ.

* Scarpa.

† Proprio humore turgidus adeo translucet ut ablongum bullulam aëream mentiatur. Scarpa, p. 47.

It was believed by anatomists formerly, that the osseous canals had the pulp of the nerve expanded on their periosteum. But we find, on the contrary, that the membranous tubuli do not touch the bones, but are connected with them by transparent cellular membrane-like mucus. Each of the semicircular membranous tubes has one extremity swelled out into an ampulla of an oval form, answering to the dilated extremity of those osseous tubes which we have already described. These ampullæ have the same structure and use with those formerly mentioned in describing the ear in fishes. When the central belly of these tubes is punctured, both the ampullæ and the membranous canals fall flaccid.

Besides those vessels which we have described running along the periosteum of the cavities of the labyrinth, vessels also play upon the sacculi and membranous tubes. The ampullæ of the tubes are, in a particular manner, supplied with blood-vessels.*

In the COCHLEA there is also a pulpy membrane, independent of the periosteum; but of this I can say nothing from my own dissection.

SECTION IV.

OF THE NERVE.

As the seventh pair of nerves arises in several fasciculi, they form what would be a flat nerve, were it not twisted into a cylindrical form adapted to the foramen auditorium. While these fasciculi are wrapped in one common coat, they are matted together. In the canal the nerve is divided nearly into two equal parts;† to the cochlea and to the vestibulum and semicircular canals. Those fasciculi, which are destined for the vestibule, are the most conspicuous; and on the portion destined for the ampullæ of the superior and external canal, there is formed a kind of knot or ganglion.

Before the auditory nerves pass through the minute foramina in the bottom of the meatus auditorius, they lay aside their coats and become more tender and of a purer white colour: and by being still further subdivided by the minute branching

* "Cæterum universum hoc canaliculorum membraneorum alveique com-"munis machinamentum sanguiferis vasis instruitur, quorum crassiora, circum "alveum communem, serpentino incessu ludunt: crebra et conferta alia "*ampullæ* imprimis recipiunt ob quam causam rubellæ plerumque sunt et "cruore veluti suffusæ." Scarpa, p. 47.

† Of the portio dura we have already spoken.

and divisions of the foramina, they cannot be followed, but finally expand in a white pulpy-like substance on the sacs and ampullæ. We must, however, recollect that there was a difference to be observed in the apparent texture of these expanded nerves in the lower animals: we may observe here, also, that part of the nerve which is expanded on the common belly or sacculus tubulorum, is spread like a fan upon the outer surface of the sac, and has a beautiful fibrous texture; but upon the inside of the sac upon which it is finally distributed it loses the fibrous appearance. We must suppose its final distribution to be in filaments so extremely minute that we may call it a pulp; though by the term it must not be understood that an unorganized matter is meant.

That part of the nerve which stretches to the ampullæ, immediately divides into an opaque white mucous-like expansion. Beyond these ampullæ, there has been no expansion of the nerve discovered in the membranous tubes.

The sacculus vestibuli* is supplied by a portion of the nerve which perforates the macula foraminulosa in the centre of the osseous excavation, or that which receives into it part of the sac. This part of the nerve is expanded in a soft mucous-like white matter in the bottom and sides of the sac.

A division of the nerve, as we have already explained, passes from the meatus auditorius internus through the cribriform base of the modiolus into the cochlea. Owing to the circular or spiral form of the foramina when the nerve is drawn out from the meatus, its extremity appears as if it had taken the impression of these foramina from the extremities of the torn nerves, preserving the same circular form. These nerves, passing along the modiolus and scalæ cochleæ are in their course subdivided to great minuteness. Part of them perforate the sides of the modiolus, whilst others pass along betwixt the two plates of the lamina spiralis, and out by the minute holes in the plates, and from betwixt their edges. Lastly, a central filament passes up through the centre of the modiolus, and rises through a cribriform part into the infundibulum to supply the infundibulum and cupola.

Where the nerves pass along the lamina spiralis, their delicate fibres are matted together into a net-work. According to the observations of Dr. Monro they are quite transparent on their extremities.

* i. e. In opposition to the sacculus tubulorum.

CHAP. V.

OF HEARING IN GENERAL.

When ærial undulations were, by the experiments on the air-pump, first proved to be the cause of sounds, philosophers looked no further to the structure of the ear than to discover an apparatus adapted to the reception of such vibrations.— When they observed the structure of the membrane of the tympanum, and its admirable capacity for receiving these motions of the atmosphere, they were satisfied, without considering the immediate objects of sensation. In the same way an ignorant person, at this day, would rest satisfied with the fact that sound was received upon the drum of the ear. But after so minutely explaining the anatomy of the ear, it becomes us to take a general survey of a structure the most beautiful which the mind can contemplate. We cannot say that it surpasses in beauty the structure of other parts of the body: but the parts are adapted to each other, in a manner so simple, efficient, and perfect, that we can better understand and appreciate the harmony of their structure than that of organs which perform their functions by qualities and actions almost entirely unintelligible to us.

We see that the external ear collects the vibrations of sound as it moves in the atmosphere with circular undulation from the sonorous body: here we may observe, that where the necessities of animals require them to be better provided with this external part of the organ than man, the superiority is only in the simple perception of sound; while man, from the perfection of the internal organ, excels all animals in the capacity of the ear for articulate and musical sounds.

From the external ear we observe, that the trumpet-like tube conveys the sound inward to the membrane of the tympanum. Behind the membrane of the tympanum, there is a cavity, which, in order to allow of the free vibration of the membrane, contains air. When this air is pent up, by the swelling, or adhesion of the eustachian tube, the elasticity of the air is diminished, and the membrane prevented from vibrating.*

* See *Recherches* &c. *rélatives à l'organe de l'ouïe et à la propagation des sons*, par M. Perolle, Sociét. R. de Médecine, tom. iii.

In the tympanum we have seen that the operation of the chain of bones is to increase the vibration received upon the membrane of the tympanum, and to transmit it to the membrane of the foramen ovale. In the cavity of the tympanum we observed two foramina, the foramen ovale and the foramen rotundum, both of which lead into the labyrinth; but one of them (the foramen ovale) into the vestibule, the other (the foramen rotundum) into the scala of the cochlea: now it becomes a question, whether the oscillations of sound pass by one or by both of these foramina?

It is the opinion of many, that while the chain of bones receives the motion of the membrane of the tympanum, the motion of this membrane at the same time causes a vibration of the air in the tympanum which reaches the foramen rotundum, and thus conveys a double motion through the cochlea.

In the labyrinth there is no air, but only an aqueous fluid: now this, we have seen, conveys a stronger impulse than the atmosphere; stronger in proportion to its greater specific gravity and want of elasticity; for an elastic fluid like air may be compressed by concussion, but an inelastic fluid must transmit fairly every degree of motion it receives. But if the fluid of the labyrinth be surrounded on all sides; if, as is really the case, there can be no free space in the labyrinth, it can partake of no motion, and is ill suited to receive the oscillations of sound. Against this perfect inertia of the fluids of the labyrinth, I conceive the FORAMEN ROTUNDUM to be a provision. It has a membrane spread over it, similar to that which closes the foramen ovale. As the foramen ovale receives the vibrations from the bones of the tympanum, they circulate through the intricate windings of the labyrinth, and are again transmitted to the air in the tympanum by the foramen rotundum. Without such an opening there could be no circulation of the vibration in the labyrinth; no motion of the fluids communicated through the contiguous sacculi, nor through the scalæ of the cochlea; because there would be an absolute and uniform resistance to the motion of the fluids.—But, as it is, the provision is beautiful. The membrane of the foramen rotundum alone gives way of all the surfaces within the labyrinth, and this leads the course of the undulations of the fluid in the labyrinth in a certain unchangeable direction.

To me it appears, that to give a double direction to the motion of the fluids, or to the vibration in the labyrinth, far from increasing the effect, would tend to annihilate the vibrations of both foramina by antagonizing them. The common idea is, that there is a motion communicated through the mem-

brane of the foramen rotundum along the scala tympani, and another through the foramen ovale into the vestibule, and through the vestibule into the scala vestibuli; and that the concussion of these meet in the infundibulum of the cochlea.— But as there is no space for motion in the fluids, in either the one or other of these tracts, the vibration must have been received in the infundibulum at the same time that the motion was communicated to the membrane of the foramen ovale and rotundum; for if a tube full of water, a mile in length, loses one drop from the extremity, there must be an instantaneous motion through the whole to supply its place. The evident consequence of this double motion would be (if they were of the same strength) to suppress all motion or vibration in the fluids of the labyrinth.

But we have shown that the strength of vibration communicated to the foramen ovale and foramen rotundum are not the same: for the mechanism of the bones in the tympanum is such as to accumulate a greater force or extent of motion on the membrana ovalis than is received upon the membrana tympani; therefore the lesser vibration which is communicated through the medium of the air in the tympanum, cannot be supposed capable of opposing the stronger vibration which circulates from the foramen ovale through the labyrinth, and returns by the foramen rotundum. Besides, the air in the tympanum has a free egress, and cannot therefore strike the membrane on the foramen rotundum forcibly.

For these several reasons, I conceive that the following account of the manner in which the sound is conveyed is erroneous:—" Et quo ad zonam cochleæ spiralem quoniam altera " cochleæ scala in vestibulo patet, altera a FENESTRA ROTUNDA " initium sumit, atque earum utraque aqua labyrinthi repleta " est, et scalæ in apice cochleæ simul communicant, zona spi- " ralis inter duas veluti undas sonoras media, a tremoribus per- " vasim stapedis, simulque ab iis per membranam *fenestra ro-* " *tundæ* advectis utraque in facie percellitur et una cum pen- " cillis acaustici nervi per eam distributis contremiscit: quibus " porro omnibus, in ampullis videlicet caniliculorum semicir- " cularium, alveo eorum communi, sacculo vestibuli spherico " et lamina cochleæ spirali acaustici nervi affectionibus audi- " tum contineri nemo non intelligit."*

As to the immediate seat of the sense of hearing, there cannot, after what has been explained regarding the distribution of the nerves, remain any controversy; though before the structure of the ear was so well understood, some imagined

* Scarpa, p. 61.

that the vestibule, others that the middle part of the semicircular canals, was the seat of hearing; others, again, that the lamina spiralis was better adapted for receiving the vibrations of sound. It is evident that the soft expansion of the nerve, in all the three divisions of the labyrinth, is destined to receive the undulation of the contained fluids, and that this motion of the fluids gives to the nerve, or to the nerve and brain conjointly, the sensation of hearing.

Since we have, in some measure, traced the structure of the ear from the animals of a simple structure to those of a more complicated organization, and have observed some parts of the ear common to all animals, some peculiar to certain orders; and since all have the sense of hearing, more or less acute, it becomes natural to inquire what are the parts of the organ the most essential to the mere perception of sound, and what parts conduce to a more perfect state of the sense.

All the external apparatus of the ear is not necessary to give the animal the simple perception of sound.—There are many classes of animals altogether without them, and even in man we see that they are not absolutely necessary; since when deprived of them by disease, man still enjoys the sense. He is deprived of no essential variety of the sensation: he is capable of perceiving the distinctions of articulate sound; and still possesses his musical ear. The external apparatus of the ear, the membrane of the tympanum, the little bones, and even the external ear, only receive, concentrate, and increase the tremors of the external air, and render the slighter impressions audible.

It would appear that the simple sac of the vestibule is sufficient to receive the impression in some animals, and that in many the vestibule and semicircular canals form solely the organ of hearing. It is evident, therefore, that these are the most essential parts. We see also an intention in the strict similarity of figure and place in these canals through all the varieties of animals, from fishes to man. It would seem to indicate, that there is in their form and position a peculiar provision for the oscillation of sound producing the full effect.

We find, however, that the cochlea is imperfect in birds: and that it is fully formed only in man, and in quadrupeds: we must, therefore, conclude, that it is subservient to the more exquisite sensations. I do not conceive that the cochlea or any part of the organ particularly conduces to the bestowing of a musical ear, although it is by hearing that we are capable of the perceptions of melody and harmony, and of all the charms of music; yet it would seem, that this depends upon

the mind, and is not an operation confined to the organ. It is enjoyed in a very different degree by those whose simple faculty of hearing is equally perfect.*

Even after studying, with all diligence, the anatomical structure of the ear, we cannot but be astonished with the varieties to be found in the sensation; for example:—" The ear " is capable of perceiving four or five hundred variations of " tone in sound, and probably as many different degrees of " strength; by combining these, we have above twenty thou- " sand simple sounds that differ either in tone or strength, sup- " posing every tone to be perfect. But it is to be observed, " that to make a perfect tone, a great many undulations of " elastic air are required, which must all be of equal duration " and extent, and follow one another with perfect regularity; " and each undulation must be made up of the advance and " recoil of innumerable particles of elastic air, whose motions " are all uniform in direction, force, and time. Hence we " may easily conceive a prodigious variety in the same tone, " arising from irregularities of it occasioned by constitution, " figure, situation, or manner of striking the sonorous body; " from the constitution of the elastic medium, or its being dis- " turbed by other motions; and from the constitution of the " ear itself upon which the impression is made. A flute, a " violin, a hautboy, a French horn, may all sound the same " tone, and be easily distinguishable. Nay, if twenty human " voices sound the same note, and with equal strength, there " will still be some difference. The same voice, while it re- " tains its proper distinctions, may yet be varied many ways: " by sickness or health, youth or age, leanness or fatness, good " or bad humour. The same words, spoken by foreigners and " natives, nay by different provinces of the same nation, may " be distinguished."†

That this variety of sensation does not entirely depend upon the structure, but is the operation of the sense and intellect conjointly, appears from the long experience which is requisite to give this perfection. Nature is bountiful in providing the means of simple and acquired perception, but the latter is the result of long experience and continued effort, though we have lost the feeling of its being originally a voluntary effort.

* See Reid's Enquiry.

† Reid's Enquiry, p 98.

CHAP. VI.

OF THE DISEASES OF THE INTERNAL EAR.

Of all the causes of deafness, that which proceeds from an organic disease of the brain, is, of course, the most dangerous. In apoplectic affections, with faltering of speech and blindness, deafness is also produced by the general affection of the brain. But worst of all is the case where a tumour of the brain, or betwixt the cerebrum and cerebellum, compresses the origin of the nerves.* I have, however, observed, that a tumour in the *vicinity* of the origin of the auditory nerve, though it ran its course so as to prove fatal, had rather a contrary effect on the organ of hearing; and while the pupil of the eye remained stationary, and the man saw indistinctly, he had a morbid acuteness of hearing. This had probably been produced by the surrounding inflammation having extended to the origins of the auditory nerves. The auditory nerve often becomes morbidly sensible, and the patient suffers by the acuteness of perception, or is distressed with the tinnitus aurium, which is, in this case, analogous to the flashes of light which sometimes affect the eye in total darkness, and which those experience who are totally blind or have cataract. So morbidly acute does the sensation sometimes become, that the slightest motion of the head will excite a sensation like the ringing of a great bell close to the ear.† With delirium, vertigo, epilepsy, hysteria, the increased sensibility of the organ becomes a source of painful sensation.

In apoplectic affections, with faltering of speech and blindness, there is also deafness; because the affection of the brain is general. With a paralytic state of the muscles of the face, there is a deafness of the corresponding ear, if the affection of the nerve be near the brain; which is explained by the strict connection betwixt the auditory nerve and the nervus commu-

* Vidit Clariss. Dom. Drelincurtius Tumorem steatomatis consistentia pugnique magnitudine, cerebrum et cerebellum inter, eo præcise loco ubi conarium utrique substeritur choroidis plexus alæ, spatio semestri a sensibili læsione, cæcitatem primo, surditatem subinde, omnium denique sensuum et functionum animalium abolitionem et necem ipsam intulisse." Bonet. vol. i. p. 123. ob. 53. In Sandifort Obs. Anatom. Path. tom. i. p. 116. there is an instance in which the auditory nerve had a cartilaginous tumour adhering to it.

† F. Hoffmann. Consult. et Respons. Cas. xxxix. We must not, however, take his reasoning after what we have seen of the structure of the ear, that viscid petuita, separated in the concha, cochlea, and labyrinth, resolved into halitus endeavouring to escape, produces the susurrus et tinnitus aurium.

nicans faciei. From observing the course of the nervous communicans faciei through the temporal bone, and its connections in the tympanum, we understand why, in violent toothach and in the tic douloureux, we find the eustachian tube and root of the tongue affected. The ear is sometimes affected by sympathy of parts: for example—from foulness of the stomach and bowels ; and the same reason may be assigned for the complaint of hypochondriacs, that they are molested with strange sounds. And in the case of intestinal worms, we find the patient complaining of murmuring and ringing in the ears.* Of the organic diseases of the labyrinth, there is little on record. It would appear, that the fluids become often so altered in their consistence as to prove an absolute destruction to the organ. Mr. Cline found in a person deaf from birth, that the whole labyrinth was filled with a substance like cheese.

A disease of the auditory nerve, like that of the retina in the gutta serena, is no unfrequent complaint.†

We ought, at all events, before proposing any operation on the ear, to observe whether the disease be not in the seat of the sense, and such as will not yield to any practice ; otherwise, as in the more important operations when done in circumstances which preclude the possibility of success, the public is impressed with its inefficacy and danger, and we are precluded from giving relief on occasions more favourable for our operations.

Deafness, in acute fever, is a good sign ; because, say authors, it argues a metastasis of the morbific matter. We should rather say, because it argues a diminution of the morbid sensibility of the brain.‡ But the surcharge of the vessels of the brain or of the auditory nerve will also produce deafness and unusual sensations in the ear ; as in suppression of the menses and hæmorrhoids, in surfeit, &c. in which cases it is often preceded by vertigo and headach.

There occurs a very curious instance of analogy betwixt the ears and eyes, in the following cases :—" A certain eminent musician, when he blew the German flute, perceived at the same time the proper sound of it and another sound of the same rhyme or measure, but of a different tone. His hearing

* Hoffmann. Med. Consult. Boerhaave. The sympathy is sometimes exerted in another way :—" Ex musices tonitru aut sola meatus auditorii externi con- " trectatione, vomitus urinæ incontinentia." Sauv.

† Dysecoea (atonica) sine organorum sonos transmittentium vitio evidente. Cullen. Cophosis *Sauv. Cophosis* a *Paracusi* distinguitur ut *amaurosis* ab *amblyopia* respectiva. Sauv.

‡ But the difficulty of knowing when the deafness is the result of disease, or malconformation in the parts transmitting the sound to the nerve, and when in the brain and nerve, has led to more uncertainty and confusion with regard to the species and varieties of the disorders of the ear than in the eye ; where the transparency of the humours assist in the definition.

seemed thus to be doubled. It was not an echo; for he heard both sounds at one and the same moment: neither were the sounds accordant and harmonious, for that would have been sweet and pleasant to his ear. Having for several days persisted in his attempts, and always been shocked with this grating sound, he at last threw his flute aside. The day before he first became sensible of this strange affection, he had imprudently walked in a very cold and damp evening, and was seized with a catarrh in the right side. Whence, probably, it arose that the natural tone of that ear was altered: the sound appeared more grave and dissonant, from that received by the left ear. Having recovered from the catarrh, the distinct hearing of his ear was restored."

Sauvage, who relates this case, subjoins another:—"Very lately," says he, "a foreigner came for advice in a similar situation. He complained that when any person spoke to him, he heard the proper sound of the voice, and at the same time another sound accompanying it an octave higher, and almost intolerable to him. As it must have happened that if the accompanying sound had preserved the true octave above the voice, and been synchronous with it, the ear would have received them as one sound, and been pleased with their concord: it is probable that the accompanying sound was not in unison with the true." Sauvage, vol. iii. p. 352.

BOOK III.

OF THE NOSE AND OF THE ORGAN OF SMELLING.

OF THE SENSE OF SMELLING.

SMELLING seems to be the least perfect of the senses. It conveys to us the simplest idea, and is the least subservient to the others. The sensations it presents to us we can less easily recall to memory: and the associations connected with it are less precise and definite than those of the senses of hearing and seeing; finally, we should lose it with less regret than any other.

Animal and vegetable bodies, during their life, growth, putrefaction, and fermentation, and, most probably, all bodies whatever, are perpetually giving out effluvia of great subtility. Those volatile particles repelling each other, or diffused in the atmosphere, are inhaled by the nose, and convey to the pituitary membrane of the nose the sensation of smell. Even in the outward form and structure of the nose, there is a relation to the exercise of the sense; the lateral cartilages of the nose, or those which form the nostrils, possess a degree of elasticity adapted to preserve the passage open and free. They have muscles adapted to move them, to expand them when greater freedom of respiration is required, and to contract them in order to diminish the stream of air, and to give it more force to penetrate to the upper cavities of the nose. The cartilage which joins to the septum of the nose is also flexible and moveable by muscles, which curve the nose or draw down the point by which in smelling, the air, which in ordinary respiration passes freely backwards, is directed upwards to the æthmoid bone; these cartilages perform another office in giving that flexibility to this prominent feature, which enables it to elude injuries and at the same time protect the bones of the

nose: but their chief use is in connection with the sense; for it may be observed, that when we draw the air in in smelling, the nostrils are compressed, which gives more force to the air received, and at the same time the direction of the stream of air is changed. When we breathe with the nostrils, stationary or expanded, the air passes directly backwards, but when it is drawn in in smelling, (the nose being drawn down,) a direction upwards is given to the stream of air, so that it is made to circulate about the cells of the æthmoid bone, where the olfactory nerve is expanded.

Immediately within the nostrils, there are two cavities separated by the bony partition, which has been already described in treating of the bones. These cavities enlarge as they proceed inward, and open backward into the throat, and consequently, communicate with the mouth. They extend upward and sideways into the cells of the bones of the face; and the pituitary membrane is extended over the surfaces of these winding passages, and over the irregular surfaces of the nose, formed by the projecting cartilages of the æthmoid and lower spongy bones; which, also, have already been sufficiently described.

The cavities of the nose lead into many cells in the bones of the face, which, though not the immediate seat of the sense, are subservient to the organ by permitting a circulation of the air, and thus carrying the effluvia into contact with the nerve. No doubt these cavities are also useful in giving vibration and tone to the voice. The cavities of the nose are continued upwards into the frontal sinuses, and into the cells of the æthmoid bone; backward and upward into the sphenoid sinus; and upon the sides into the antra Highmoriana or sinuses of the upper maxillary bones.

The membrane covering the surface of these bones is called the MEMBRANA SCHNEIDERIANA, the mucous or pituitary membrane. It is of a glandular structure, or is lubricated by the mucus discharged by the follicules on its surface. This secretion on the surface of the membrane, is to defend its delicate and sensible structure from the effects of the air, while it preserves the sensibility of the surface and the delicate expanded nerve. It seems of a nature to allow the effluvia to penetrate it.

A very particular provision has been made against the too powerful effect of smells while the membrane is inflamed, and consequently, in a state of great sensibility. When the membrane is inflamed, the secretion is altered, and the effluvia does not penetrate, nor does it affect the nerve in its state of extreme sensibility.

We have already described the course of the first pair of nerves or the olfactory nerves, and also those branches of the common nerves which are distributed to the membrane of the nose. These, it were superfluous to recapitulate here. The olfactory nerve alone is the organ of smelling, and the branches of the fifth pair bestow merely the common sensibility which is enjoyed promiscuously over the body.

I have traced branches of the fifth nerve into all the cavities of the face, and we feel that they possess sensibility. Thus in applying volatile salts to the nostrils, we can distinguish a painful sensation rise into the frontal sinuses different from the sense of smelling. When the root of the nose has been broken in and the cavity opened, experiments have been made by sending effluvia upwards into the frontal bone, and no sense of odours was experienced; but when they were admitted downwards to the æthmoid bone, the first nerve was affected, and the sense exercised. This sensible and nervous membrane, being also glandular and secreting, is very vascular; and this vascularity, this glandular structure, and its exposed state, makes it liable to frequent disease: and, when diseased, when tumours and polypi form in it, we must never forget the extreme thinness and delicacy of the surrounding bones, which, when they are either pressed upon by tumours, or have their membranes eroded, are soon totally destroyed. It is with manifest design, that the organ which so particularly admonishes us of the effluvia diffused in the air we breathe, should have been placed in the entrance to the canal of the lungs. It is, in some measure, a guard to the lungs, as the sensibility of the tongue guards the alimentary canal. That the humidity of the membrane either preserves the sensibility of the nose, or is a solvent, in which the effluvia dissolving affect the nerves, is evident; for the sense is lost when the membrane becomes dried. The sensibility is also affected in various ways by too abundant a mucous discharge, or by an alteration of its natural properties; by the infarction and thickening of the membrane, as in ozæna; by obstructions preventing the current of air through the nose, as in polypi, &c.

The acuteness of sensation in this organ is most probably lost by our habits, by our relying on other senses, by the incessant application of artificial odours to the organ. Those who have believed in the variety of the human species, and the approximation of some tribes to the brute, dwell much on the acuteness of sensation enjoyed by negroes, and their wider nostrils.*

* *Pallas* says, the Calmuck by applying his nose to the hole of a fox, or any other beast, can tell whether he be at home or not.—See *White of Manchester*.

There is nothing more curious than the spontaneous exercise of the organs of the senses. Thus we have bad taste in the mouth. Ringing in the ears. Sparks of fire before the eyes, when there has been no outward impression made upon the organ; and so have we rarer examples of disease putting even the organ of smelling into exercise. A young gentleman, a student, was attacked with a complaint in his Schneiderian membrane, which changed the nature of its secretions. During this disease he was assailed with the most disagreeable odours, a circumstance not so uncommon; but the unplèasant exercise of the sense was sometimes relieved by his experiencing the most delightful and fragrant effluvia, which after all were not in existence, but proceeded either from the spontaneous operation of the organ of sense, or from morbid irritation upon it.

There has been a most interesting communication made to me by Mr. Thomas, of two examples of ossification in the anterior part of the falx, in two men who were related to each other, and who, during the latter part of their lives, were disturbed by the most offensive smells, which had no existence but in the irritation of these bony excrescences on the olfactory nerve.

BOOK IV.

OF THE MOUTH, SALIVARY GLANDS, AND ORGAN OF TASTE.

CHAP. I.

OF THE MOUTH AND TONGUE.

THE mouth is that cavity anterior to the velum or fleshy palate; the posterior cavity is the fauces; the mouth is for mastication and speech, the posterior cavity is a common passage, admitting the food to be conveyed into the œsophagus, and the air to be drawn in from the nostrils into the trachea.

The lips and cheeks are formed of the skin and reflected mucous membrane, with muscular fibres intervening to give them pliancy and motion, and with minute glands to discharge the moisture on their inner surfaces.

The glands of the lips are called *glandulæ labiales* and are very numerous, those of the cheeks are called the *glandulæ buccales*.

OF THE TONGUE.

The BODY of the tongue consists of muscular fibres, with intermingled fat and cellular membrane; and the muscles which chiefly compose it, are the linguales, styloglossi, and genioglossi muscles.

The BASE of the tongue is that part which is connected with the os hyoides, the apex is anterior.

The surface applied to the roof of the mouth is called DORSUM; and on this surface there is to be observed a middle line, dividing the tongue into two lateral portions; a division which is very accurately preserved in the distribution of the blood-vessels and nerves of either side. On the dorsum, towards the base, the surface is rough with the papillæ maximæ and foramen cæcum Morgagni.* These papillæ are like small glands seated in little superficial fossulæ, so that their broad mushroom-like heads alone are seen; but they are connected

* Adversar. Anat. VI. Animad. XCIII.

with the bottom of the fossulæ by short stems or necks. This is considered a glandular apparatus. The foramen cæcum is, in truth, only an enlarged apparatus of the same kind, for, in the bottom of this foramen, many glandular papillæ stand up; and in its bottom small foramina have been observed, which are generally conceived to be the mouths of small salivary ducts. Morgagni himself, however, seems only to have seen a small duct opening into this foramen in one subject of many which he examined. In *Haller's opuscula* there is a dissertation on the *Duct of Cosckwizianus*, which was supposed to carry the saliva from the sublingual gland to the middle of the tongue, and also into the throat, but it turns out to be a vein only. It is curious to observe the necessity the author discovered for these ducts, when he thought he had found them.* This secreting mucous surface begins here, towards the root of the tongue, to resemble the glandular structure of the œsophagus, which by bedewing the surface of the morsel, fits it for an easy passage through the gullet. To me it seems that this roughness of the root of the tongue is a provision for the detention of the sapid particles, and the prolonging of the sensations of taste.

The PAPILLÆ of the human tongue are divided into four classes. 1. These larger papillæ upon the root of the tongue are the truncatæ; and they are often studded on the dorsum of the tongue in a triangular form. 2. The fungiformes are obtuse papillæ found more forward on the tongue; they are little hemispherical tumid papillæ, with an obtuse surface. These are interspersed among the 3d division, the most numerous and universally prevalent papillæ, viz. villosi or conoideæ; they are, as Soemmerring says, of various forms, angular, conical, obtuse. 4. The vaginatæ are the more important papillæ, however; they are endowed with peculiar sensibility to sapid bodies; are to be distinguished by their superior redness and brilliancy, and are placed upon the point and edges of the tongue.

The tongue is invested with the cuticle and rete mucosum, like the skin in other parts. The lower surface of the tongue is similar to the general lining membrane of the mouth, being a villous and secreting surface. It is reflected off upon the bottom of the mouth. It forms here the FRENULUM LINGUÆ. This ligament seems evidently intended to limit the motion of the point of the tongue backwards. I believe a very false opinion has much prevailed, that the shortness of this ligament,

* Vater, who injected these ducts, found them terminating in a gland near the os hyoides; and his opinion was, that they had even a connection with the thyroid gland. Heister was of the same opinion.

or its being continued too far forward toward the point of the tongue, prevents the child from sucking. The tongue, as I conceive, would sufficiently perform the necessary action on the mother's nipple, although its lower surface were universally adhering to the bottom of the mouth. But, observe the bad consequences which may arise from cutting this frenulum, and yielding to the obstinate importunity of the nurse. The ranine vein or artery which runs near it may be cut, and the child will continue sucking and swallowing its own blood ; and children have actually died, and the stomach has been found distended with blood! But there is another more dreadful accident from this cutting of the frenum linguæ. A child, says Mr. Petit, whose frenum had been cut almost immediately after its birth, was suffocated and died five hours afterwards. They believed that the operation was the cause of the child's death ; they sent for me to open the body. I put my finger into its mouth, and I did not find the point of the tongue, but only a mass of flesh which stopped up the passage from the mouth into the throat. I cut up the cheeks to the masseter muscles, to see what had become of the tongue ; I found it turned like a valve upon the fauces, and the point actually swallowed into the pharynx. "Some time after," continues Mr. Petit, "I was called to the child of Mr. Varin, Sellier du Roi, whose frenum they had cut two hours after its birth, and who, a little after, had fallen into the same situation with the child I have now mentioned, and was nearly suffocated. My first care was to introduce my finger: the tongue was not, as yet, entirely reversed into the throat. I brought it back into the mouth ; in doing which, it made a noise like a piston when drawn out of its syringe." Mr. Petit waited to find the effect of its sucking, and, after hearing the action of deglutition for some minutes, the child fell into the same state of suffocation. Several times he reduced the tongue, and, at last, contrived a bandage to preserve it in its place ; but, by the carelessness of the nurse, the accident recurred, and the child was suffocated during the night.

CHAP. II.

OF THE SALIVARY GLANDS.

The sources of the saliva are very numerous ; the parotid glands or superior maxillary gland, and socia parotidis, the in-

ferior maxillary or submaxillary glands; the sublingual glands; and (according to the opinion of many) the glandular follicules of the root of the tongue: the palate, and even the buccales and labiales, or glands of the cheeks and lips, are also to be enumerated as sources of saliva.

The PAROTID GLAND, as its name implies, is that which lies near to the ear. It is the largest of the salivary glands; and it is of much importance for the surgeon to observe its extent and connections. A great part of it lies before the ear, and betwixt the ear and jaw. It extends over the masseter muscle, and upward to the zygoma. But there is also a great part of it which lies below the tip of the ear, and betwixt the angle of the jaw and the mastoid process. Its surface is unequal, and composed of little masses or lobules of gland, united by a cellular membrane. The duct of this gland was discovered by Needam, and afterwards by Steno: it is very often called Steno's duct. When it is injected with quicksilver, the branches are seen distributed in a most beautiful and minute manner amongst the lobuli of the gland, and similar to the branching of veins. These branches have a direction upward, and unite into a trunk, which passes from the upper part of the gland across the cheek over the origin of the masseter muscle: it then pierces the buccinator muscle, and opens upon the inner surface of the cheek, opposite to the second dens molaris. This duct has strong white coats; but, although the mouth of the duct is very small, the duct itself is dilatable to a great size, so that tubes of a considerable size have slipt into it, and been buried in the body of the gland.

The SOCIA PAROTIDIS is a small gland, (which, however, is by no means constant,) seated on the upper side of the duct of the parotid gland, and just under the margin of the cheek-bone. It opens by a lesser duct into the great duct of Steno. Sometimes, however, instead of one considerable gland, there are several small ones, seated in the course of the great duct, and opening into it by several minute ducts.

OF THE SUBMAXILLARY AND SUBLINGUAL GLANDS. The submaxillary gland is of a regular oval figure; it lies under the platysma myoides on the tendon of the digastric muscle; it is defended by the angle of the lower jaw, while it is generally connected with or involves the root of the facial artery. It is regularly lobulated; and its duct passes forward between the genio-glossus and mylo-hyoideus, and under the sublingual gland. The openings of the submaxillary ducts, or ducts of Wharton, are very easily distinguished. They open under the tongue very near each other on each side of the frenum linguæ; so that they appear as if tied down by the frenum.

When these are excited to discharge their fluids, they become a little erected, their patent mouths are seen distinctly, and the tortuous course of their canal in the bottom of the mouth may be observed.

The SUBLINGUAL GLAND is of a flat and elongated form; it lies close under the tongue between the genio-hyo-glossus and mylo-hyoideus muscles. It is the smallest of the three great salivary glands. The two sublingual glands stretching closely under the tongue, they are separated from the mouth only by the membrane of the mouth. The duct of the sublingual gland opens into the duct of Wharton at the same time that it opens by small lateral ducts, with loose pendulous mouths upon the lower surface of the tongue. The *glandula molaris* is seated betwixt the masseter and buccinator muscles: it properly belongs to the class *buccales*.

From the general surface of the lips, tongue, cheek, and palate, there is a fluid exhaled. This exhaling surface, and all those glands, are excited to action by the same stimulus with the membrane of the mouth. The saliva moistens the surface of the mouth, assists in manducation, and preparing the food to be swallowed and acted upon by the stomach, and accelerates digestion. As the mouth is an exhaling surface, so is it an imbibing and absorbing surface. Calomel may be rubbed upon the mouth so as to salivate.

CHAP. III.

VELUM PALATINUM; UVULA; ARCHES OF THE PALATE; AND AMYGDALÆ.

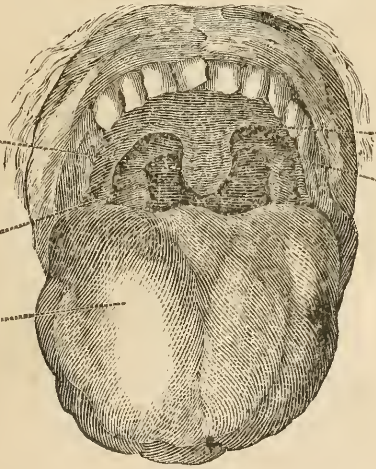
THE VELUM PENDULUM PALATI is the vascular and fleshy membrane, which, hanging from the bones of the palate, divides the mouth from the fauces. It is not a simple membrane, but has betwixt its liminæ many glands, which open upon its surface by little follicules, and is thickened and strengthened by muscular fibres: so that it is more of a fleshy partition, stretching backward and eking out the palate, than a hanging membrane.

The edge of the velum palati is not square, but turned into elegant arches; and, from the middle of the arches of the pa-

late, hangs down the UVULA, so named from its resemblance to a grape. It is a large, soft and glandular papilla, peculiarly irritable and moveable, having in it muscular fibres, and hanging from the moveable soft palate. It seems to hang as a guard over the fauces, and by its sensibility, in a great degree governs the operation of these parts. It is also part of the organ of the voice.

The ARCHES OF THE PALATE OR FAUCES descend on each side from the velum palati. They are muscular fibres, covered with the soft vascular and follicular membrane of the fauces.* There are two on each side. These arches stand at some distance from each other, so that the isthmus of the fauces resembles the double-arched gateway of a citadel, or the arched roof of a cathedral, with the uvula hanging as from the central union of four semicircular arches.

Fig. 20.



Behind the soft palate is the opening of the nose backward into the throat. Now, the use of the velum is, that in swallowing, it may be drawn up like a valve upon the posterior opening of the nose; and there being, at the same time, an action of the arches of the palate, the whole is brought into a funnel-like shape, directing the morsel into the pharynx and gullet. In this action the direction of the food assists, but, in vomiting, the valvular action of the velum is not so accurate; and often the nose is assailed with the contents of the

* See Vol. I. Constrictor Isthmi faucium and Palato-pharyngeus.

stomach. The velum also is a principal part of the organ of the voice.

Amygdalæ. Betwixt the arches of the palate on each side, lies a large oval gland of the size and shape of an almond. These are the tonsils or amygdalæ. The amygdala is a mucous gland: it is loosely covered with the investing membrane of these parts: its surface is seen, even in a living person, to be full of large cells like lacunæ; these communicate; and the lesser mouths of the ducts open into them. On a narrower inspection of the amygdala, I describe its structure thus: within the arch of the palate, and before the arch of the fauces, there is a fossa of an oval shape, and on the surface of the membrane a number of cells open like the mouths of veins. These do not appear to me to communicate. When the arches and the amygdala are dissected out behind these holes, we feel a gland, as it were one solid body; but on further dissection from behind, the cellular membrane being taken away, instead of one large gland there appear a number of lesser ones. These glands discharge their secretions into the oblique passages which are seen on the membrane of the throat, and from these lacunæ the mucus is pressed out when the morsel is pressed backward. From this naturally loose texture, and from its being a vascular and secreting body, exposed to the immediate vicissitudes of weather, the amygdala is often inflamed, and greatly impedes the action of the surrounding muscular fibres in the action of deglutition. The use of the amygdala is evidently to lubricate the passage of the throat, and facilitate the swallowing of the morsel: and, for this reason, are the mouths of its ducts cellular and irregular, that they may retain the mucus until ejected by the action of deglutition. In this operation, the amygdalæ are assisted by numerous lesser glands, which extend all over the arches of the palate and pharynx. But these are parts which come again to be recapitulated, as introductory to the account of the structure of the œsophagus and stomach, in the succeeding part of the work.

CHAP. IV.

OF THE SENSE OF TASTING.

On the surface of the tongue are to be observed many papillæ,* in which the extremities of the gustatory nerve terminate: they are the seat of the sense of tasting. These papillæ are in the true skin of the tongue, and are extremely vascular. They are covered by the rete mucosum, and a very fine cuticle, and, indeed, they have much resemblance to the papillæ of the skin. These papillæ, which are the organs of taste, are to be seen on the point and edge of the tongue, and consist of a pretty large vascular soft point which projects from an opaque and white sheath. If we take a pencil and a little vinegar, and touch or even rub it strongly on the surface of the tongue, where those papillæ are not, the sensation only of a cold liquid is felt: but when you touch one of these papillæ with the point of the brush, and at the same time apply a magnifying glass, it is seen to stand erect and rise conspicuously from its sheath, and the acid taste is felt to pass as it were backward to the root of the tongue. The exquisitely sensible papillæ are placed only on the point and edge of the tongue; for the middle of the tongue is rough and scabrous, not to give the sensation of taste, but to force the sapid juices from the morsel, or break down the solids against the roof of the mouth, and assist in their solution. The more delicate and vascular papillæ would be exposed to injury if situated on the middle of the tongue. Before we taste, the substance dissolved in the saliva flows over the edges and point of the tongue, and then only comes in contact with the organ of taste.

It would appear that every thing, which affects the taste, must be soluble in the saliva; for without being dissolved in this fluid, it cannot enter readily into the pores and inequalities of the tongue's surface.

A curious circumstance, in the sense of taste, is its subserviency to the act of swallowing. When a morsel is in the mouth and the taste is perfect, our enjoyment is not full: there follows such a state of excitement in the uvula and fauces, that we are irresistibly led to allow the morsel to fall back-

* Albinus Ann. Acad. lib. i. cap. xv.

ward, when the tongue and muscles of the fauces seize upon it with a voracious and convulsive grasp, and convey it into the stomach. The measure of enjoyment is then full. This last short-lived gout is the acmè. Were not this appetite of the throat and uvula connected with the action which impels the food into the stomach, the complete enjoyment of the sense of taste alone would satisfy, and would have rendered unnecessary the disgusting practice of the Roman Gourmand, who forced himself to vomit that he might resume the enjoyment of eating. But, as it is, the connection of the stomach and tongue is such, that the fulness of the stomach precludes the further enjoyment of the sense of taste. The senses of smelling and taste have their natural appetites or relish; but they have also their acquired appetites, or delight in things which to unsophisticated nature are disagreeable: so that we acquire a liking to snuff, tobacco, spirits, and opium. "Nature, indeed, seems studiously to have set bounds to the pleasures and pains we have by these two senses, and to have confined them within very narrow limits, that we might not place any part of our happiness in them; there being hardly any smell or taste so disagreeable that use will not make it tolerable, and at last, perhaps, agreeable; nor any so agreeable as not to lose its relish by constant use. Neither is there any pleasure or pain of these senses which is not introduced or followed by some degree of its contrary which nearly balances it. So that we may here apply the beautiful allegory of the divine Socrates: that although pleasure and pain are contrary in their nature, and their faces look different ways, yet Jupiter hath tied them so together, that he who lays hold of the one draws the other along with it."

BOOK V.

OF THE SKIN AND OF THE SENSE OF TOUCH.

OF THE SKIN.

THE skin is divisible, by the art of the anatomist, into four laminæ or membranes, distinct in texture and appearance, and use, viz. the *cuticle*, or *epidermis;* the *corpus mucosum*, or reticular tissue; the *cutis vera*, *dermis corium*, or true skin: but from the surface of this last there is separated a *vascular membrane*, below which is the surface of the true skin; lastly, we may enumerate the tela cellulosa as constituting a part of the general integument.

The CUTICLE, or EPIDERMIS, or SCARF SKIN, is the most superficial of these layers: it is a transparent and insensible pellicle which serves, in some degree, to resist the impression of external bodies on the surface of the body, and to blunt the otherwise too acute sensation of the cutis vera.* In man it is very thin, unless in those parts which are exposed to the contact of hard bodies, as the palms of the hands and soles of the feet. The thickness of the cuticle there, however, is not altogether the effect of labour and walking, but there is even in the early fœtus a provision for the defence of the skin of the feet, by the supply of a thicker cuticle. When the cuticle is drawn from its foot the sole is white, opaque, and thick, whilst, in the leg, it is transparent and more delicate.† This is also particular, that by labour or continued pressure on the cuticle it does not abrade and become thin and tender, but thicker, harder, and the part more insensible, so as even to acquire a horny hardness and transparency. Of this we have an example in the hands of smiths and other workmen, and in a remarkable manner in the feet of those who have been accustomed to walk bare-foot on the burning sands. It is thus a protection to the foot in a state of nature. But if the skin be too much or too quickly exerted, instead of forming additional layers of cuticle, a serous fluid is thrown out from the true

* It is unaccountable that so great a man as Morgagni could suppose the cuticle to be the mere effect of air and pressure on the surface of the true skin. Adversar. Anatom. III. 3.

† *Albini, Annot. Acad.*

skin, which separates the cuticle in blisters; and this over-action of the skin will throw off the cuticle, as we see to be the consequence of the irritation of plasters or cataplasms, scalding water, exanthematous diseases, erysipelas and mortifications, &c. When the foot comes to be unnaturally pinched in shoes the hard leather works perpetually on a point of the toes, and blisters the feet; but if in a lesser degree and longer continued it excites the formation of cuticle in the skin below, which thrown outward by succeeding layers of cuticle, at last forms a corn or clavus, and which, like a small nail, has a broad head with a conical point shooting into the tender skin.*

The cuticle is perforated by the extremities of the perspiring and absorbing vessels, and by the ducts of the glands of the skin, and by the hairs. Indeed, when the small pores of the skin or foramina are examined narrowly, the cuticle is seen to form sheaths which enter into them, and which, when torn out, are like little tubes having a perforated point; for when, by maceration, the cuticle is separated from the skin, as we draw it off we see little processes of the cuticle, which enter into the pores of the skin.

In the dead body the cuticle may be separated by permitting putrefaction to go on, and for this purpose, the skin is put in maceration:† Ruysch separated it by extending a portion of skin and pouring boiling water upon it.‡ Vesalius and Malpighi practised the coarser way of carrying a red hot iron near the skin.

Mr. Cruickshanks enumerates three classes of processes of the cuticle: there appear evidently two. The first lines the pores through which the hairs pass: these are the longest. The second class is easily distinguished on the inside of the cuticle, which covers the palms of the hands or soles of the feet, or indeed on any part of the cuticle; and they appear in regular order on those parts of the cuticle which correspond with the parallel or spiral ridges of the cutis: these enter into the pores of the true skin. The surface of the cuticle is uniform next the skin; but, on the outer surface, it is rough and squamous. These squamæ are the portions of the cuticle, which, breaking up, are rubbed off; for there is a perpetual change, by the formation of new cuticle under the old, and the abrasion or desquamation of the old surface.

When I say that the cuticle is uniform I must not forget to speak of the regular lines observable on both its surfaces, and

* De clavo pedis, vide Albinus, Acad. Annot. lib. vi. cap. vi. et vide tab. ii. fig. 1.

† Santorini Observ. Anat. cap. i. § i.

‡ De hum. C. fabrica, lib. ii. c. 6.

which are especially observable on the tips of the fingers, and which are a very particular part of the organ of touch.

The ulcerative process has no power over the cuticle, so that when the matter of an abscess has reached the cuticle, its progress is stopt until the cuticle is burst by the distention. This is the reason of the greater pain of abscesses in the soles of the feet and palms of the hand, where the cuticle is very strong.*

OF THE STRUCTURE AND GROWTH OF THE NAILS.

The nails are naturally connected with the cuticle, for they remain attached to it: in exanthematous diseases, when the cuticle exfoliates, the nails are also pushed off; and in death they both separate from the true skin by maceration and beginning putrefaction. The nails are to give firmness and resistance to the points of the fingers. Although they take a very universal adhesion, it is chiefly from the root that they grow and shoot out to the point of the fingers, to which they adhere firmly. Over the root of the nail the cuticle projects, and under it the rete mucosum is extended; and under this, and defended by it, are the papillæ of the skin.

Like the cuticle, the nails are without vessels or sensation: they are undergoing a perpetual growth, by thin roots, and are worn down by labour. When cherished, they grow to an amazing length, and curve a little over the points of the fingers; and serve in some nations as a most unequivocal sign of the person so ornamented being above the necessity of keeping herself. It was supposed that the nails were formed by the extremities of the tendons, which extending beyond the flesh were dried and hardened;† and the celebrated Albinus describes the nail as formed by the conversion of the papillæ which lie under it‡: they are generally conceived to be a continuation of the epidermis.§

But saying that the nails are continuations of the cuticle, though true, is saying nothing.—We cannot believe, even on the authority of Albinus, that the nervous filaments which lie fasciculated under the nail are converted into the nail, merely because the under surface of the nail is reticulated like these filaments. For it is evidently reticulated like the soft filaments, in order to give lodgement to them, to have a corresponding surface with them.

* See Hunter on Blood and Inflam. p. 469.

† *Riolanus.*

‡ Annot. Acad. vol. i. lib. ii. cap. iv.

§ Winslow.

The nails differ from the cuticle in not scaling or exfoliating like it, but in growing from a root like a hair.

OF THE HAIRS.

The hairs grow from a bulbous root, seated in the cellular membrane. This bulb is vascular, and has connection, by vessels, with the cellular texture. It consists of a double membrane; the outer is a kind of capsule which surrounds the other, and stops at the pore in the skin, and does not form part of the hair. Betwixt these capsules, there is a cellular tissue, and the space is commonly found filled with a bloody fluid. In the bottom of the inner sac, there is a small body, called monticule by Duverney, from which the hair is seen to arise; and if this is left when the bulb of the hair is pulled out, the hair will be regenerated.

The root of the hairs, says Winslow, is covered by a strong white membrane, which is connected with the skin and cellular membrane. Within the root, there is a kind of glue, some fine filaments of which advance to form the stem, which passes through the small extremity of the bulb to the skin. As the stem passes through the root, the outer membrane is elongated in form of a tube, which closely invests the stem, and is entirely united with it. And many authors agree, that the hair does not perforate the cuticle, but takes from it a vagina which accompanies it in all its length.*

The hair serves as a distinction in the human tribes. The European has the longest hair, next to him the Asiatic, then the American, and lastly the African.† A common opinion is entertained that hair on the body is a mark of strength; but I have observed our famous boxers, when in high condition, are smooth, fair, and clear in the complexion of their bodies; while men of a dark sallow hue are generally hairy on the trunk and shoulders. Betwixt hair and wool, or betwixt the hair on different parts of the body, there is no distinction in the anatomical structure. In the growth of hair and wool, however, there is a difference. They are both produced annually; but wool is shed at once and leaves the animal bare, whilst the hair falls off gradually, and the young and the old hairs are together growing at the same time. Hair is of uniform thickness in its whole length; whereas wool is variable in the thickness of its filament;—further it has been found, that

* Vide quæ de hoc *Albinus* Animadvertit. Acad. Annot. l. vi. cap. ix. and *Morgagni* Adversar. et Epist. An. iii. § 4.

† Mr. White of Manchester tells he has seen a lady with hair six feet in length;—a Prussian soldier whose hair trailed on the ground.

the thicker part grows during the warmer times of the season; that it is thicker in summer, and finer in the spring and autumn. This shows us how the fleece becomes coarse and hairy in a warm climate.

RETE MUCOSUM.

THE rete or corpus mucosum, or Reticulum Malpighi, lies betwixt the cuticle and the surface of the true skin. It is a mucous layer, pervaded by the little fibrillæ passing betwixt the skin and cuticle. I consider it as a soft bed to envelope and preserve the papillæ of the skin, and as intended to become cuticle in due succession. It was considered, by Albinus, as of a nature adapted to imbibe the fluids through the cuticle, and as a production of the epidermis. Mickle believed it to be only a mucous fluid, inspissated into the form of a membrane; and that it was dissolved by putrefaction, while the skin and cuticle remained firm. It is the seat of colour in the skin, and is of a white transparency in the albino, and in the inhabitants of temperate climates. It is black in the negro; copper coloured in the mulatto; yellow in the Egyptian.* It is supposed to preserve the negro from the heat of the climate; but I conceive that the power of resisting the rays of the sun in warm climates, must be looked for in other constitutional peculiarities; for certainly a surface which absorbs the light must produce heat more rapidly than a white one, which repels it.† The rete mucosum changes its shades of colour in Europeans, from the effect of light; but this tanning seems to have no strict resemblance to the permanent colour of the negro skin. It soon reaches its maximum by the influence of the sun, and soon wears off again. And this degree of blackness does not attach to the offspring.‡ When

* Malpighi de sede negridinis in Ethiope. It has appeared to me that there was a great deal of colour in the cuticle of the negro, and so Morgagni, "negricante et fusco colore infectas." Adversar. II. Animad. IV. See also Blumenbach de generis humani Varietate. The colour of the skin belongs to tribes, and is only in a certain degree affected by climate. *Humboldt*, Essaie Politique sur la Nouvelle Espagne, observes that climate, which has such an effect on Europeans, has little or none on the Indian complexion: tribes of a temperate climate are darker than those inhabiting a province less cool and temperate. The Indians on the tops of the Andes are as dark as the inhabitants of the plains. Humboldt also asserts (contrary to Volney) that, in the provinces of Spanish America, the children of Indians are copper coloured from the moment of their birth.

† Priestley's Experiments.

‡ The Gradation in Man, by Charles White, of Manchester.—Some have said that extreme cold also tans the skin, as the Esquimaux Indians, and Greenlanders, are dark; opposed to this, we find the Finlanders and Norwegians fair beyond other Europeans. There is much in the habits of life; a painter will not find his carnation tints amongst the poor—nor in the skin of a Highlander; yet where so pure as in a Highland lady?

the rete mucosum is destroyed by ulceration, it is imperfectly regenerated, and does not possess its former colour. In a negro the inner surface of the rete mucosum is blacker than the outer surface; the inner surface of the cuticle is softer and darker than the outer surface.* Mr. White argues, that if this blackness were the effect of the sun, that part most exposed would be the blackest. But though I agree with him in thinking that the blackness of the negro is not owing to climate, yet I see this argument of his is incorrect; for it is not the direct influence of the sun which tans; no such effect comes of exposing dead skin; it is the excitement of the living vascular surface in the formation of new matter, or the discharge of colouring matter in the rete mucosum.

While the rete mucosum has its peculiar use of defending the delicate surface of the papillæ of the skin, I conceive it to be undergoing a perpetual change: to be thrown off in succession from the vascular surface of the skin, and in its turn to form the cuticle by its outer layers. The inner surface of the rete mucosum is softer and more pulpy, the outward surface more allied to the cuticle, which gives occasion to Mr. Cruickshanks to say it is double.

VASCULAR MEMBRANE OF THE TRUE SKIN.

Under the rete mucosum, and on the surface of the skin, there is a soft vascular membrane, which is still above the porous and glandular true skin. It was first demonstrated by injections in subjects who had died of small-pox, and is also so much strengthened by other inflammatory actions of the vessels of the skin, as to be capable of demonstration. It was at first supposed that this vascular membrane was the rete mucosum successfully injected; but afterwards it was found, that this vascular membrane existed independently of this rete mucosum.† Mr. Cruickshanks conceives that it is cuticle in its state of formation, and that the rete mucosum is in fact a cuticle advancing to the state of perfect maturation. But I should rather believe that this is a vascular surface, not changeable, nor losing its vascularity, to be thrown off in form of rete mu-

* Mr. White of Manchester, on the Gradation of Man, in the plate from a preparation of Mr. Cruickshanks. For opinions regarding the cause of colour in the skin, see *Albinus de sede et causa Coloris Æthiopium, Sugd. Batav.* 1737. *Haller Element. Physiolog. vid. pag.* 20.—*Blumenbach de generis humani varietate nativa Gottingæ*, 1795, page 122, and note.

† Mr. Baynham, who discovered this vascular surface, conceived that he had injected the rete mucosum. Ruysch and others mentioned by Albinus, supposed they had injected the cuticle when most probably they had torn off the vascular membrane, or as *Albinus* alleges, Acad. Annot. lib. vii. c. iii. in taking off the cuticle they had torn up the vascular papillæ along with it.

cosum: but, in itself, the organized surface, which is to secrete the rete mucosum, and which secretion does in succession become cuticle. This vascular surface of the skin, for such I must suppose it, (although it be capable of being separated by long maceration and putrefaction, into something like a distinct membrane,) is the seat of the small-pox pustule, and probably all other cutaneous diseases.*

Thus there are three laminæ above the true skin, distinguished by their character; the cuticle, the rete mucosum, and the vascular membrane: but as some have divided the rete mucosum into laminæ, Mr. Cruickshanks has separated two vascular layers from the surface of the skin. They who are fond of such minute subdivisions, may thus enumerate five laminæ or membranes, before coming to the porous surface of the true skin.

OF THE TRUE SKIN.

The true skin is the dense, elastic, and vascular membrane which is under these outer layers already treated of. It consists of a net-work of firm filaments, having in their protection sebaceous glands, exhalent and absorbent vessels, nerves, the papillæ or organized extremities of the nerves, and the roots of the hairs. These are sufficient to give it both some substance and firmness. While it has substance, strength, and elasticity to defend the body, it is also an organized surface, as important in its function, and the healthy action of the system depending upon it nearly as closely as on the action of the lungs and surface of the intestines.

The skin is dense on the outer surface, while the internal layers are loose, and gradually degenerate into the cellular substance. Our soldiers and sailors have a way of marking their skins with gunpowder or with vermilion, which is indelible. They prick the skin and insert the colouring matter into it, where it remains without producing inflammation, and unabsorbed. But this is no proof of the unchangeable nature of the skin as regards its colour, or whatever else may distinguish the nations and tribes of man.†

We have to attend to the pores and villi of the skin: on narrowly observing the surface of the skin, we find it irregularly porous. These are the ducts of sebaceous glands, which are lodged in the skin. They transmit the hairs also, and are the perspiring, and, probably, the absorbing pores; or, at least,

* Of the slough of the small-pox pustule, see Dr. Adams's Morbid Poisons. Appendix.

† I allude to the ingenious essay of the *Rev. S. S. Smith*, of the American Philosoph. Society, on the causes of the variety in the human complexion and colour.

within these larger pores the absorbing and transpiring vessels terminate. These pores are most remarkable about the nose, mouth, palms of the hands, and soles of the feet. Into these pores of the true skin, as we have mentioned, little sheaths of the cuticle enter, and through these sheaths the perspiring matter must consequently escape: but perspiration is the action of living parts; in death, the action of the perspiring vessels ceasing, the pores of the cuticle are no longer pervious to the fluids, and there is no perspiration or exudation through them; even when the dead surface is exposed to heat, it dries only where the cuticle is off.

OF THE ORGAN OF TOUCH.*

The villi of the skin project above its surface, like the pile of velvet. They vary much in size, and in some places are very much prolonged. They conduct the sensible extremities of the cutaneous nerves to form the organ of the sense of touching;† I see that these sentient filaments are very vascular at their extremities. When the hand is minutely injected, and there seems a general blush of redness over it; when the cuticle is taken off, and we examine the villi with a powerful magnifying glass, their extremities are seen bulbous and red. We know that even in nerves there is no sensibility without blood be supplied, and I look upon this high degree of vascularity as a provision for great sensibility.

These fine filaments are placed in the softest bed possible. Examine the minute ridges of the cuticle, and you may distinguish them to be quite regular; the ridge which is prominent external corresponds with a depression or minute sulcus within. In these sulci, or in the interstices of the ridges of the cuticle, there is a soft matter in which the villi lie secure, yet ready to receive the impression made on the insensible cuticle.

Of the nature of the sensation conveyed by the nerves of the sense of touch we are as ignorant as of that conveyed by the other nerves. Some are accustomed to consider this as an inferior sense, for no better reason than that it is more common to the surface of the body, whereas it is the most important, and that which ministers to the other senses and to our necessities most of all;—it is the sense necessary to the existence of every living creature.

* Albinus Dissertatio de Sede et Caus. Color. Æthiop. Malphigi, et Exercit de Tact. Organ.

† Vide de Papillis Cutis, *Albini*, Ac. Annot. lib. vi. c. x. and Ruysch.

Nay more, it is that sense which gives correctness to all the others, at least if we are right in attributing so much to the exercise of this sense; as hardness, softness, solidity, figure, extension, and motion. If the sense of touch be that change arising in the mind from the application of external bodies to the skin, then certainly the organ has high exercise, and is of all the senses the most valuable. But it appears to me that these qualities, of hardness, softness, solidity, figure, extension and motion, would be known to us, although we had no nerves in our finger ends at all! These qualities belong to what I would call the muscular sense, that conception of distance which we acquire by moving our body or our members, by pressing upon an object and feeling the resistance it occasions. Much might be said on this subject, but it is evident that these two senses, that of motion or action, and of feeling, must be closely allied and mutually useful to each other.

FUNCTION OF THE SKIN.

The function of the skin has a very extensive connection with the due performance of the internal organs of the animal economy.

The perspired matter from the skin consists principally of water and carbon. The carbonic acid produced in the process, is by the union of the carbon with the oxygen of the atmosphere. The perspired fluid holds also in solution several salts and recrementitious matter of animal substance.

Besides the insensible perspiration there is an oily exudation from the glands of the skin, which appears to be useful in giving pliancy and softness to the scales of the cuticle. This oily secretion is copiously secreted in the negro; and it appears as a means of protection against the powerful influence of the sun, in as much as it prevents the cracking and breaking of the squamæ of the cuticle. It preserves the skin soft and perspirable. The softness of the negro's skin is remarkable; and this softness and coolness of the skin is observable in all degrees of propinquity to the negro.

It has been long observed that the surface of the body, immersed in water, gave out bubbles of air. Lavoisier found that thin air precipitated lime water. Cruickshanks, Abernethy, Jurin, continued these experiments illustrative of this function of the skin in giving out carbonic acid; but these have been overthrown by Professor Woodhouse, of Philadelphia, who proved that the air so collected upon the surface was attracted from the water, not exhaled by the surface.

Nevertheless carbon is discharged by the skin, and the quantity is found to depend on the vigour of circulation, and of the constitution; and when discharged from the skin as I have said, the attraction of the oxygen of the atmosphere forms the carbonic acid. Thus the function of the skin is brought to resemble, in the most essential particular, the function of the lungs; and I believe all animal surfaces whatever will be found to partake of this function, the discharge of the useless carbon from the system.

The powers of the human system are, in all respects, superior to that of brutes; and the provision for the human body inhabiting the different climates of the globe, is most particular. It has been proved that man, for a short time, can support existence in a heat of 260 of Far. It is proved, that while he can live in indulgence under the line, he can inhabit a country so cold as to drive away the white bear of the polar regions. A ship's crew have wintered in 76 of northern latitude, and the powers of the living body sustained life while spirits and mercury were frozen.

Although there are experiments by Dr. Fordyce, which prove that animals possess a power of resisting heat independent of perspiration, still undoubtedly, the free or checked perspiration of the surface is a means of equalizing the temperature of the body.

According to the activity of the circulation is the heat of the body, and according to the activity of the circulation is the perspiration in health. By this perspiration, and the change of the perspired fluid unto vapour, the heat of the body is carried off. In a cold atmosphere, perspiration ceasing, the vital heat is retained; in a warm atmosphere, the perspiring action being excited, the heat of the body is prevented, or rather carried off.

The authorities are contradictory in regard to the absorption by the surface, unaided by friction, abrasion, or ulceration.*

The more important function of the surface is to be contemplated in its effect on the general activity of the vascular system, and in the vicarious action which takes place betwixt it, the stomach and intestines, and the kidney and lungs. The similarity of function performed in the lungs and by the skin would lead us to attend to the injury of the former by the impression of cold on the surface and the checked perspiration. The fact that perspiration is altered in degree by the progress of digestion, would lead us to attend to the many occasions in

* Rollo on Diabetes, Dr. Currie, Abbe Fontana, Dr. Watson.

which we see the disorders of the viscera effecting changes on the skin; the imperfection of the function of perspiration, when digestion and the function of the viscera are deranged, would lead us not only to mark the symptoms of internal disease on the skin, but to take the means of exciting the latter as a remedy for the former. In the same manner will the secretion of the kidney be influenced by the state of the skin and of perspiration: need I add that the health and strength of the circulation, and of course the health of all the functions, is influenced by the excitement of the skin. Some practitioners take the stomach, and others the bowels, and others the liver, on which they harp continually; let any one take the skin as his object of care, and his practice will have equal success, his cases and facts become soon as numerous, while his connection with general science will be more intimate; and if he introduce his system by showing that health is enjoyed when the various functions, which together form the animal economy, are perfect, and that one function cannot be in health without the whole be also, he will, in my opinion, have better claims to public favour than any who have yet flourished in it by promulgating doctrines in regard to the functions and diseases of individual parts.

EXPLANATION OF THE PLATES.

Explanation of Plate 30.

FIG. 1.

THE eye with the cornea cut away, and the sclerotic coat dissected back.*

a. The OPTIC NERVE.

b. The SCLEROTIC COAT dissected back, so as to show the vessels and nerves of the choroid coat.

cc. The CILIARY NERVES seen piercing the sclerotic coat, and passing forward to be distributed to the iris.

d. A small nerve passing from the same source to the same destination, but appearing to give off no branches.

ee. Two of the VENÆ VORTICOSÆ.

f. A point of the sclerotic coat through which the trunk of one of the veins had passed.

g. A lesser venous trunk.

h. The orbiculus ciliaris of Zinn; the ciliary ligaments of others.

i. The IRIS.

k. The straight fibres of the iris.

l. A circle of fibres or vessels which divide the iris into the larger circle k, and the lesser circle m.

m. This points to the lesser circle of the iris.

n. The fibres of the lesser circle.

o. The pupil.

FIG. 2.

A dissection of the coats of the eye, as they appeared when hung in spirits.

* See Zinn, Tab. iv.

Fig.

2

A. The OPTIC NERVE.
B. The SCLEROTIC COAT folded back.
C. The CHOROID COAT hanging by its attachment to the sclerotic coat.
D. The vessels of the RETINA seen as they appeared suspended in the fluid ; the medullary part of this coat being washed away.

Explanation of Plate 31.

FIG. 1.

The LENS covered with its capsule, and minutely injected in the fœtus calf.

A. The ARTERIA CENTRALIS RETINÆ.
B. The fringe remaining with the margin of the lens from the attachment of the vessels of the ciliary body.

FIG. 2.

This figure shows the attachment of the capsule of the lens to the membrana pupillaris, in the fœtus calf.

A. The capsule of the lens very minutely injected ; the lens has been allowed to escape, and the membrane hangs by its attachment to the membrana pupillaris.
B. That part of the capsule which covers the forepart of the lens ; in which not a vessel is to be seen.
C. The MEMBRANA PUPILLARIS, very minutely injected.
D. The IRIS, to the circle of which, the membrana pupillaris is seen to be attached, and consequently, to close the pupil.
E. The CILIARY PROCESSES.

FIG 3.

The CILIARY PROCESSES, the IRIS, and MEMBRANA PUPILLARIS, as they appear in the human fœtus of the seventh month.

FIG. 4.

The appearance of a vessel which took its course across the pupil in the full grown fœtus, indicating that the membrana pupillaris was still present, although it had become pellucid.

FIG. 5.

A section of the optic nerve, to show its great degree of vascularity.

A. The body of the nerve quite red with injection.
B. The coat of the nerve.

Explanation of Plate 32.

FIG. 1.

The representation of an eye with a cataract, dissected.

A. The CORNEA cut from the sclerotic coat, and hanging by a shred.
B. The SCLEROTIC COAT.
C. The IRIS.
D. The OPAQUE LENS OF CATARACT; it is seen to have formed an adhesion with the iris.

FIG. 2.

This figure represents the effect of couching a soft cataract. The needle, instead of depressing the cataract, cut it into three pieces.

AA. The cut edge of the SCLEROTIC COAT.
B. The CHOROID COAT, and CILIARY PROCESSES.
C. The cataract adhering to the ciliary processes in three distinct pieces.

FIG. 3.

This figure represents the place into which the couching needle must be introduced.

A. The PUPIL seen through the transparent cornea.
B. The IRIS.
C. The NEEDLE, with the handle elevated, so as to depress the point.
D. The lens and point of the needle in outline: this represents the position of the lens when depressed: to complete the operation, it must be carried a little back before withdrawing the needle.

FIG. 4.

A scheme, showing the bad effect of introducing the needle near the margin of the cornea.

A. The VITREOUS HUMOUR.
B. The LENS.
CC. The CILIARY BODY; on the lower part torn by the needle.
DD. The IRIS.
E. The anterior chamber of the aqueous humour.

FIG. 5.

Shows the situation of the cataract when depressed.

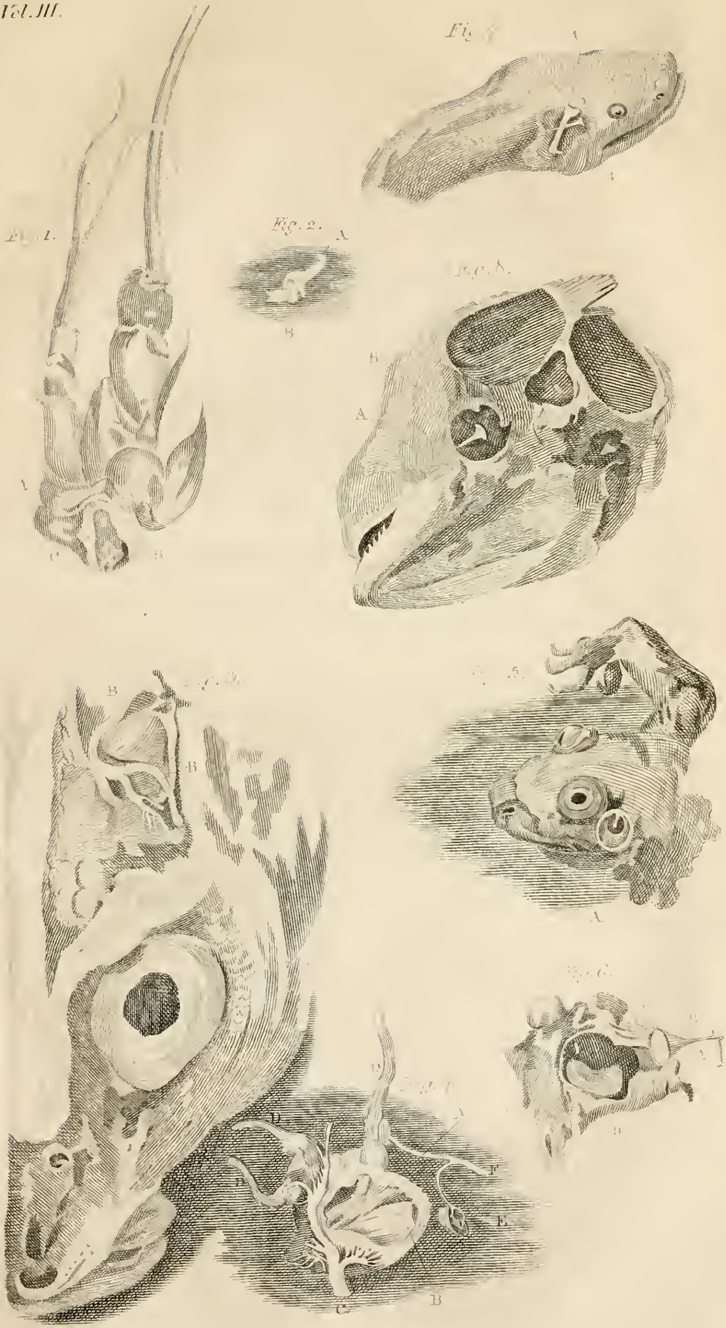
A. The ANTERIOR CHAMBER of the aqueous humour.
B. The POSTERIOR CHAMBER of the aqueous humour.
C. The IRIS.
D. The VITREOUS HUMOUR occupying the seat of the lens.
E. The depressed lens or cataract.

Explanation of plate 33.

Showing some varieties in the structure of the ear in the lower animals.

FIG. 1.

The ear of the lobster.



del.

Leney fc.

A. The membrane which covers the projecting m ouh cf the shell containing the organ of hearing.

B. A transparent pulp or vesicle, upon the bottom of which the web of the nerve is expanded.

C. The inside of the shell containing the organ, which is, of course, represented broken open.

FIG. 2.

This represents a little bone which is suspended in contact with the pulp of the nerve, and which is seen but imperfectly in the first figure.

A. The bone.

B. An elastic membranous, or rather cartilaginous substance, by which the bone is suspended.

FIG. 3.

The head of a haddock, with the bones broken up, to show the brain and semicircular canals.

A. The BRAIN.

B. The SEMICIRCULAR CANALS.

FIG. 4.

The organ of hearing taken out and displayed.

A. The SACCULUS VESTIBULI.

B. The bony concretion which lies within, and which, by its vibration, increases the impulse.

C. The AUDITORY NERVE passing to be distributed on the sacculus vestibuli, and the extremities of the semicircular canals.

D. D. D. The SEMICIRCULAR CANALS.

E. One of the extremities of the semicircular canals, in which the branch of the nerve is seen to be expanded.

F. A lesser division of the auditory nerve.

FIG. 5.

The head of a frog with the skin taken off: and we now see the cavity of the tympanum in this animal, over which the common integuments of the head spread tense, so as to answer the purpose of the membrana tympani.

A. The point of a little elastic bone which is attached behind the tense integuments, and receives their vibration. Its further connections are seen in the next figure.

FIG. 6.

A magnified view of the internal structure of the frog's ear.

A. The first bone, which is attached to the skin.

B. The second bone, which has its inner extremity enlarged so as to fill up the foramen ovale, which leads into the inner cavity of the ear.

C. The great inner cavity of the ear of this animal, answering to the vestibule of the more perfect structure.

D. A chalky concretion which lies within this cavity.

FIG. 7.

The head of a serpent.

A. A bone connected with the lower jaw.

B. A bone which passes from the integuments (behind the large bone A) to the opening into the cavity of the ear, and which, of course, receives and conveys the vibration of sound into the cavity which contains the expanded nerve.

FIG. 8.

The HEAD of the LAND TORTOISE.

A. A large scale which serves the use of the membrana tympani.

B. A single bone which is seen to pass through the cavity of the tympanum; it is attached by an elastic brush of fibres to the scale A, and is enlarged to a head upon its inner extremity. This, filling up the foramen of the inner cavity, conveys the vibration.

Explanation of Plate 34.

In this plate, the anatomy of the bones of the human ear is explained.

FIG. 1.

We have here the bones which form the chain betwixt the membrane of the tympanum and the membrane of the foramen ovale.

A. The MALLEUS.

B. The INCUS.

C. The STAPES.

D. The OS ORBICULARE, which forms the articulation betwixt the incus and stapes.

FIG. 2.

In this figure we have a view of the inside of the temporal bone, the petrous portion being broken away: we see the cavity of the tympanum, the membrane of the tympanum, and the chain of bones.

A. The groove for the lodgment of the lateral sinus.

B. The hole in the sphenoid for the passage of the artery of the dura mater.

C. The petrous portion of the temporal bone.

D. The irregular CAVITY of the TYMPANUM laid open by the breaking off of the petrous part of the temporal bone.

E. The MEMBRANE of the tympanum closing the bottom of the meatus auditorius externus.

F. The MALLEUS, the long handle of which is seen to be attached to the membrane of the tympanum E.

G. The INCUS, united to the great head of the malleus F.

Fig. 1

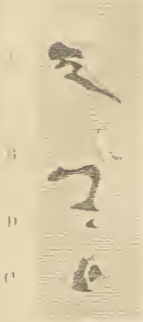


Fig. 2.

Fig. 4

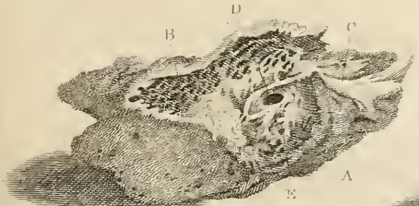
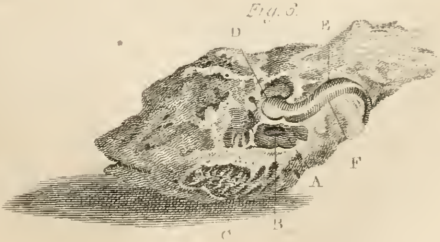


Fig. 3.

Fig. 5.

Fig. 6.



Bell del.t Leney sc.t

Fig 1

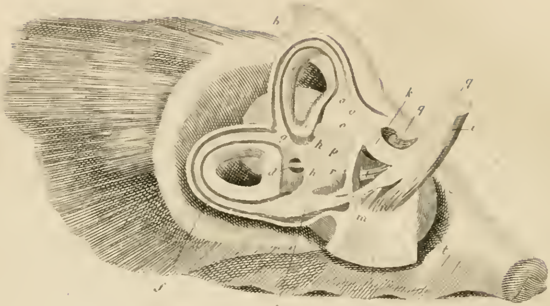
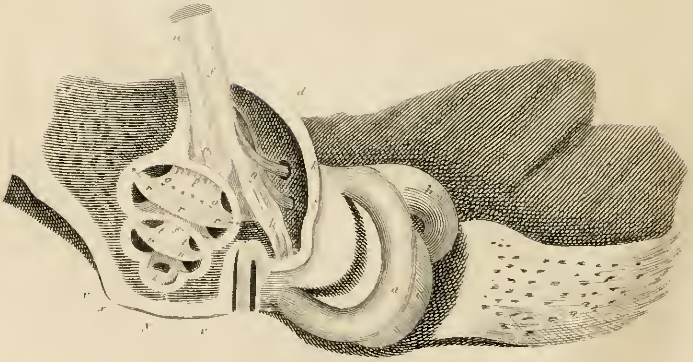


Fig 2



Bell del. Lizars sc.

H. The STAPES, which is seen to be articulated with the long extremity of the incus through the intervention of the os orbiculara.

FIG. 3.

Shows the division of the temporal bone into the squamous and petrous portions.

A. The SQUAMOUS PART of the temporal bone.

B. The CIRCULAR RING, which forms the meatus auditorius externus in the child.

C. The ZYGOMATIC PROCESS.

D. Cells which afterwards enlarge into those of the mastoid process.

FIG. 4.

The petrous portion of the bone, with a view of the tympanum.

A. The CAVITY of the TYMPANUM.

B. MASTOID CELLS.

D. The FORAMEN OVALE, into which the stapes (see fig. 1. C. and fig. 2. H.) is lodged.

E. The more irregular opening of the FORAMEN ROTUNDUM.

FIG. 5.

Represents the labyrinth of the human ear, with the solid bone which surrounds it cut away.

A. The FORAMEN OVALE.

B. The three SEMICIRCULAR CANALS.

D. The COCHLEA.

E. The tube which conducts the portio dura of the seventh pair through the temporal bone.

FIG. 6.

Explains the manner in which the lamina spiralis divides the cochlea into two scalæ, and the opening of the one scala into the common cavity of the vestibule, and the termination of the other in the foramen rotundum.

A. The bone broken so as to show the cavity of the tympanum.

B. The FORAMEN OVALE.

C. Cellular structure of the bone.

D. The FORAMEN ROTUNDUM.

E. One of the SCALÆ of the cochlea which is seen to terminate in the foramen rotundum.

F. The other scala, which is seen to communicate with the vestibule.

Explanation of Plate 35.

These two figures are taken from the beautiful plates of the

Professor Scarpa, and illustrate the soft parts contained within the osseous labyrinth, and the distribution of the nerves.

FIG. 1.

There is seen the membranous semicircular canals, their common belly, and the distribution of the acoustic or auditory nerve.

a. The AMPULLA of the superior membranous semicircular canal.
b. The SUPERIOR MEMBRANOUS SEMICIRCULAR CANAL.
c. The AMPULLA of the external membranous canal.
d. The other extremity of the external canal.
e. The AMPULLA of the posterior membranous semicircular canal.
f. The POSTERIOR SEMICIRCULAR CANAL.
g. The common canal of the superior and posterior canal.
h h. The sac common to the membranous semicircular canals, viz. the ALVEUS COMMUNIS.
i. The body or trunk of the ACAUSTIC NERVE.
k. The larger branch of the nerve.
l. A filament of the nerve to the sacculus vestibuli.
m. The lesser branch of the acaustic nerve.
n. A filament to the cochlea.
o o. Filaments of the larger branch of the acaustic nerve to the ampullæ of the superior and exterior semicircular canals.
p. The expansion of the nerve on the common alveus.
q q. NERVUS COMMUNICANS FACIEI or PORTIA DURA.
r. The beginning of the spiral lamina of the cochlea.
s. The osseous canal of the nerve, which forms part of the foramen auditorius internus.
t. The COCHLEA.

FIG. 2.

The distribution of the nerve in the cochlea seen by a section of the internal auditory canal and cochlea.

a. The SUPERIOR OSSEOUS SEMICIRCULAR CANAL.
b. The posterior osseous semicircular canal.
c. The external osseous semicircular canal.
d. The bottom of the great FORAMEN AUDITORIUM INTERNUM.
e. The trunk of the great acaustic nerve.
f. The ANTERIOR FASCICULUS of the acaustic nerve.
g. A plexiform twisting in the anterior fasciculus of the nerve.
h. A gangliform swelling of the nerve.
i. The greater branch of the anterior fasciculus.
k. The lesser branch.
l. A filament of the anterior fasciculus to the hemispherical vesicle of the vestibule.

m. A branch to the beginning of the lamina spiralis.
n. The POSTERIOR FASCICULUS of the acoustic nerve.
o. The filaments about to enter the tractus spiralis foraminulosus.
p. These nerves seen upon the modiolus.
q q. The filaments of the nerve passing forward betwixt the two planes of the lamina spiralis.
r r. Their termination on the soft part of the lamina spiralis.
s. The nerves expanded on the second gyrus of the modiolus.
t t. u. u. Their further distribution on the lamina spiralis.
v v. The INFUNDIBULUM.
x y. The last turn and termination of the lamina spiralis in the infundibulum.

THE

ANATOMY

OF THE

VISCERA OF THE ABDOMEN.

INTRODUCTION.

VIEW OF THE SYSTEM OF THE VISCERA, AND OF THE STRUCTURE OF GLANDS.

IN this last division of the work we have to comprehend the anatomy and functions of the several viscera of the abdomen and pelvis: we must consider them not only as individual parts, but as connected together, and as forming with the lymphatic and circulating systems of vessels a great part of that chain of mutual dependence and relation which constitutes the animal economy a whole. It becomes necessary, therefore, to take here a general and cursory view of the economy of the intestinal canal and absorbing system, including at the same time something of the history of opinions regarding secretion and the structure of glands. It will be understood, that these introductory observations are meant only to combine the several parts, and to prevent that manner of description, which is necessary to accuracy and minuteness, from leading us to consider the several parts as distinct and insulated.

An animal body is never for a moment stationary: the remotest part is in action, and is suffering a perpetual change. From the first moment of our existence we have commenced a revolution: we, by slow degrees, advance in activity and strength, and ripen to maturity: but by as slow and as sure gradations we decline to feebleness and infirmities; and the more rapidly that animals advance in the first stage of their progress, so is their decline proportioned.

But it is not in observing the changes of the animal body from youth to age that the operations of the economy appear the most interesting. It is when we find the living body to consist of parts performing a variety of functions, and these connected and mutually dependent; when we see the circulating fluid throwing out fluid and solid secretions to build up and support the body, which is in incessant and daily decay. Again, our admiration must be strongly excited when we observe the system to consist of fluids and solids, and the existence of the animal to depend upon the balance of their power; the fluids separating and combining in new affinities, and forming the various secretions; and the solids having action, and that action controlling the affinities and new combinations of the circulating fluids. We find that life subsists by the due action of solids and fluids: or that an incomprehensible influence in a living body is exerted on the latter, and that the chemist can never so combine the fluids out of the body as to imitate the changes produced in a living system of fluids and vessels. Forgetting that animation is the essential character of living bodies, that it influences the chemical affinities, and varies the attraction of particles, physiologists have too much endeavoured to explain the phenomena of animated nature by illustrations formally drawn from mechanics, and hydraulics, and in the present day from chemistry.

In a body in which there is life, there is a perpetual waste; first by secretions, which for particular purposes are thrown into the cavities, and afterwards carried out of the body entirely, by the excretions of the kidney, by the perspiration from the surface, the exhalation by the lungs, the secretions of the intestines. But more than this, there is a decomposition of the solids of the body which are carried into the circulating fluids, and finally dismissed from the system. Lastly, we cannot but observe, that even the powers of muscular motion, nay, the powers of the mind and of the senses, are exhausted by exercise, and renovated through the influence of the circulation. The continued action of a muscle is followed by feebleness, and the continued impression of the rays of light exhausts the retina, so that the object becomes first faint and then vanishes.

Since there is waste of the solids and fluids, and exhaustion of the energies of the system, so also must there be a source of supply, and means of renewing its activity, and there must be a perpetual motion in the particles of the living frame. Accordingly, animals have appetites requiring the supply of food and drink, and the call of hunger and thirst stand in relation to the necessities of the body. When food is received into the first passages, there is thrown out from the stomach a fluid

which dissolves it, changes its properties, and is itself essentially altered. The work of assimilation is thus begun. As this converted fluid takes its course through the intestines, it is more and more changed; more assimilated to the nature of the peculiar fluids of the animal; and having still additional secretions united to it, particularly the bile, it is by these means separated from the grosser parts of the aliment. This fluid, which is now called chyle, is absorbed by a particular and appropriate system of vessels, which, from their conveying this white and milky-like fluid, are called the lacteals: The lacteal vessels carry the chyle to the thoracic duct, the trunk of the absorbing system; but not directly; for the chyle is deposited in the mesenteric glands, from which it is again absorbed and carried forward. Or if we suppose these glands to be merely convoluted vessels, its flow is at least delayed, so that it is not at once thrown into the mass of circulating fluids.

We find then that the stomach performs digestion, and the spleen, we will venture to affirm, is subservient to it. The secretion of the liver we find to prepare the chyle for absorption, while at the same time it is the peculiar stimulus to the intestines. The pancreas pours out a fluid which tempers the acrid bile. The superior part of the intestinal canal absorbs the nutritious fluid or chyle, while the gross remains of the food move on to be deposited in the great intestines. The great intestines are not only receptacles, but form at the same time an extensive secreting surface useful in the economy, by throwing off the waste of the system.

The lacteal vessels, which take up the chyle, are but branches of the system of absorbents—which is a system consisting of two great divisions, the lacteals and lymphatics: the first receiving the nutritious fluids from the intestinal canal, and the latter being absorbents, taking up the fluids which have been thrown out upon the cavities and surfaces of the body; and we presume upon their absorbing the solid parts of the body also. Thus the new fluids, rich in supplies, are mingled with those which are fraught with the waste and decomposition of the system. The thoracic duct, the trunk of this system, conveys these fluids thus mingled together into the right side of the heart, where they are received into the vortex of the circulating red blood. These fluids, now agitated and wrought up with the blood in the cavities of the heart, are sent through the circulation of the lungs, and submitted to the influence of their action and the exposure to the atmospheric air.

When chyle is formed in the stomach and intestines, it is observed to consist of albumen, serum, globules, and salts: but the change which it may undergo by its reception into the

lacteals, its being deposited in their glands, its mingling with the lymph, its agitation in the heart, have not been observed, though it is natural to suppose that by degrees it assimilates in its nature to that of the circulating blood, and does at last become perfectly similar by the operation of the lungs.

By the exposure of the circulating fluids to the atmosphere in the lungs, the carbon of the blood is thrown off, and the blood, resuming its purity, is again suited to circulate in the body.

That the blood of an animal has properties which distinguish it from mere matter we readily allow; but to say that it possesses life is to use a term in which few will acquiesce. It possesses properties while circulating in the vessels distinct from those which it shows out of the body; and these do not depend on the agitation and incessant motion, nor on the degree of heat, nor on any similar circumstance, but apparently on some secret influence which the vessels exert over it. The analysis of the blood by the chemists holds out to us little hope of advancing in the knowledge of the economy of a living animal. Chemistry, when applied to the analysis of animal matter, leaves its devotees in a perplexity of knowledge and discoveries which have no end, and which point to no conclusion.

There are produced from the blood a variety of fluids by organs which are called glands, and the formation or separation of these fluids is secretion. But the solid parts of the body ought to be considered as secretions equally with the matter which flows from the ducts of glands. For there is formed and deposited from the blood, during the round of its circulation, bone to support the incumbent weight of the body; muscular fibre, to give it motion; as well as all the other variety of solids and fluids. The only difference betwixt these solid depositions from the blood and the glandular secretions is, that the former are still within the influence of the vascular system, and that they are decomposed and re-absorbed, conveyed again into the mass of circulating fluids before they can be finally expelled from the body.

The chemists have observed the division of animal bodies into solids and fluids, but the subdivisions of these are very inaccurate. The fluids they have distinguished into three classes; 1st, Recrementitious humours, which go to nourish and support the body: 2dly, The excrementitious fluids, which are carried out of the body by certain emunctuaries; and the 3d are of a compound nature, being partly recrementitious and partly excrementitious. We must observe, however, that the fluids enumerated under these heads show it to be a very incorrect arrangement. The *first* division comprehends the fat, the

marrow, the matter of internal perspiration, and the osseous juice. The *second* comprehends the fluids of insensible transpiration, the sweat, mucus, cerumen, urine, fæces. And the *last* division comprehends the saliva, the tears, the bile, the pancreatic juice, the gastric and the intestinal juice, the milk, and the seminal fluid. To attend to their arrangements of the solid parts of animals would be equally remote from serving any useful end; for they have thrown together parts so discordant in function and so unlike in structure that they can be of no use in a general view of the economy, and cannot in chemical analysis show a uniform result.*

Perhaps all the correctness to which we can at present pretend is some such division as this. Besides forming the solid mass of the animal body, these secretions are drawn from the blood; fluids which are subservient to the assimilating of new matter to the system; fluids which are useful in preserving the mobility of parts; and, lastly, the secretions which convey away the waste and debris of the body, which is successively replaced by the apposition of new matter.

From this short view of the system we understand how incessantly the powers are spent in action, and the fluids exhausted by deposition and secretion, and how essential to life the functions of those parts are which act upon and assimilate the food. It is the consideration of these parts which forms the subject of the first section of what remains of the present volume. As in the consideration of these functions the structure of the glandular organs becomes a chief subject of inquiry, it will be natural at present to consider in a general way the opinions which have been entertained regarding their structure.

The peculiar nature of that organization by which the several secretions are formed, has hitherto eluded absolute proof by experiment or dissection. It is imagined that there are some organs which do little more than separate the parts of the blood like to the exudation by exhaling arteries. But neither in the exhalent arteries, nor in the simple organs, can I imagine a simple straining of the blood, but rather that the same principle of activity influences all, and that the several varieties of secretion depend upon an action modified by the living property in the secreting part. It would appear that the fluids in circulation and the vessels containing them must reciprocally affect each other: we know that a change on the state of the circulating fluids will alter the nature of the glandular action, and an excitement of the gland will still more

* See Fourcroy's Analysis of Animal Substances.

powerfully change the nature of the secretion; the active power of the solids appearing to be an agent which controls and directs the chemical affinities.

The term gland is applied to certain solid and firm bodies, with regular and smooth surfaces, which are in great number over the whole body. The functions of many of these bodies are known. They are found to have ducts which convey from them a secreted fluid; but in many of them we discover no duct, and can but obscurely guess at their use.

We are struck with the variety of form in the secreting organs. We see a simple surface pouring out its fluids; or a simple canal into which the arteries throw out the secretion. We find again the secreting vessels and their ducts convoluted and massed together, forming such glandular bodies as I have just mentioned; of which kind are the solid abdominal viscera. In the glandular viscera there are greater varieties in form than in any of the other parts of the body; and with these variations there is no corresponding change of function. I am of opinion that the forms of the solid abdominal viscera result entirely from their situation. The liver is convex upwards, because the diaphragm is concave; and it is irregularly concave downwards, because in contact with the duodenum, colon, and gall-bladder. The same may be said of the spleen, the pancreas, the kidney: their form has reference to place, and has nothing further to do with their functions.

When we dissect the glands we do not find them to have a similarity in structure. Thus the substance of the liver, the kidney, the testicle, &c. are quite unlike, and as their secretions are different, so are their sympathies: the effect of disease upon them, and the consequences of medicine operating through the general circulation, will be to attach to one individually, leaving the others in their accustomed action. There is also a very remarkable difference in the length, size, and form of blood-vessels passing into the glands.

In considering the opinions of physiologists or anatomists regarding glandular secretion, and the structure of glands, we find in the first instance that the old physicians contented themselves with saying that the glands or viscera possessed a peculiar power to select and separate the fluids from the blood. The next class had recourse to hypothesis; they spoke of the separation of certain parts by means of fermentation,* or by a kind of filtering through the pores or vessels of glands; that these pores allowed only particles of a particular size or figure

* Van Helmont. Vieussens, &c

to pass them.* It was opposed to this hypothesis, that the thinner fluids must have run through the organs destined for the grosser secretions. But when a theory such as this is received, no argument nor proof seems necessary to overthrow it. Resting upon authority alone, it stood until it was overturned by the fashion of new doctrines: one equally puerile was raised upon its overthrow.

We observe, says the founder of this theory,† that wet or oiled paper will only transmit fluid of that kind with which it is previously imbued, it will not transmit the oil when wetted, nor will the water make any impression on the paper when previously oiled. Upon these facts are to be raised a theory of secretion! Betwixt the secreting vessels and the ducts, in the peculiar tissue of which glandular structure consists, there is interposed a fluid of that particular kind which is required to be secreted, and when the blood is driven against this tissue so imbued, no fluid but of nature resembling that already deposited can be transmitted. By this hypothesis they explained secretion, making it to depend on the attraction and repulsion of the particles of the blood by fluids previously secreted. We may surely leave this class of physiologists accounting for the original depositation of the fluids in the glands without a wish to search with them further into this mystery. Commentators on this theory, by taking into the system the action of the nerves, indicated that they did not altogether forget that the body was alive.‡

Another set of physiologists attributed the whole effect of secretion to the velocity of the blood in the glands or secreting vessels ;§ others, to the length and curves of the vessels, and their action upon the fluids. Again, others have been satisfied with the round assertion, that the vital action was the essential cause of secretion. This, it ought to be understood, must be universally acquiesced in, while yet there may remain an inquiry as to the structure and means employed. Disappointed in obtaining an unexceptionable general theory of secretion, we are only enabled to conclude, that while a power exists in an animal body, directing its actions, perhaps both in the solids and fluids, and particularly in the mutual influence which they exert, the form, length, and activity of the vessels and ducts give opportunity to the greater or less degree of intricacy in the operation of the principles upon which the secretion depends.

Let us then attend to the observations of anatomists, and to

* Charleton, Descartes, Borelli, Verheyn, &c. &c. † Winslow. Helvetius.
‡ Conor, Tentamen epistolare de Secretione. § Boerhaave, Pitcarne, &c.

the appearance which the GLANDULAR VISCERA present under the knife.

It is not perfectly clear what the older anatomists meant by the expression Parenchyma. It would appear however to have saved them the trouble of investigation. They meant flesh, yet not muscular substance, but such as the liver presents. This matter they seem to have conceived to be formed by the blood. Thus Highmore describes the liver to be formed of the blood of the umbilical vein: the opinion originally of Erasistratus.

Previous to the time of Malpighi it is fruitless to trace the opinion of anatomists regarding the structure of glands. He was the first who sought to throw light upon this obscure subject by anatomical investigation, and he made a more rapid progress than has been done by any man since his day. If we take into consideration the difficulties he had to encounter in a new field, and the prejudices of the learned with which he had to combat, his merits will be found greater than even those of Ruysch. The opinions of Malpighi were received by those who, forsaking the authorities of names, saw the importance of the study of anatomy. Ruysch himself gave credit to the opinions of Malpighi in the early part of his life. But Ruysch's more attentive observations being in contradiction to those of Malpighi, his maturer judgment rejected that anatomist's proofs, and with a boldness in which he was never remarkably deficient he invented a new theory, or at least alleged new facts, and swayed men's opinions with an absolute authority.

MALPIGHI was an Italian, and born near to Bologna. Whilst yet a young man, being sunk under the accumulation of family distress, absorbed in grief, and lost to the consideration of his interest, he received comfort and assistance from his master, who urged him to embrace the medical profession. His progress was rapid. After studying at Padua, he was called to fill one of the chairs in Bologna. He was then solicited by Ferdinand II., Duke of Tuscany, to be professor in the university of Pisa. Here he was associated with liberal men: and now only in his second professorship did he learn to despise the scholastic learning of the time, and betook himself to experiment as the only means by which philosophy could be raised from the oppressive barbarism of the schools. Malpighi and Borelli were associated; they dissected together; they suggested thoughts to each other; they doubted, and canvassed freely each other's opinion; and were to each other an excitement and encouragement to perseverance and industry. They were supported by government; popular in their teaching; while they collected round them the learned men of the

time. This was the origin of the famous Academy del Cimento. Malpighi was, after this, professor in Messene, and died in the Quirinal palace at Rome, of a stroke of the apoplexy,* after having been some time physician to Pope Innocent XII. Malpighi had many enemies, and even some of his colleagues were animated against him with a dishonourable jealousy. Many laughed at his studies and occupations as frivolous and absurd. Something must be allowed for men who had laboured with diligence to become learned; for these, his opponents, had passed their lives in the study of the Arabian writers. With them studies were enforced which held science in subjection; studies which, in place of invigorating, served only to chill and paralize exertion, and retard ingenious investigation. Even Borelli, but from other motives, opposed and censured some of the dissertations of Malpighi.

Malpighi has been considered as the inventor of this department of anatomy, which the French, curious in distinctions, have called the analytic method. He showed the impropriety of the term Parenchyma, as applied to the substance of glands. He proved that the lungs, for example, (which they also called Parenchymatous,) were not fleshy, and had no resemblance to the glandular viscera of the abdomen. He taught, that though glands are smooth on their outer surface, they consist of lobules connected by cellular membrane; and, upon a still more minute investigation, that they consist of innumerable little follicules or sacs; that these are interposed betwixt the arteries which convey the fluids and the excretory ducts going out from them; that the arteries, or the vasa efferentia, after ramifying and encircling these bodies, pierce them and secrete the fluids into them. On other occasions he describes these little glandular bodies as appended to the ramifications of the arteries, like fruit hanging by the branches of a tree.

Malpighi threw in his liquid injections: dissected and examined with the microscope; made careful observations and experiments on living animals; and, lastly, attended in a particular manner to the phenomena of disease. By disease, no doubt, parts swell out and are magnified, and become distinct; but it is not a test of the natural structure, or implicitly to be trusted to.

* Much coagulated blood was found in the ventricles of his brain by Baglivi.

Scheme of Malpighi's opinion.

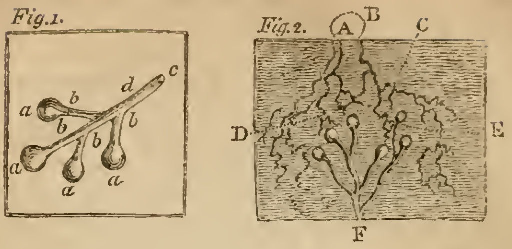


Fig. 1. Boerhaave's plan of Malpighi's doctrine. *a a a* folliculos glandularum simplicissimarum denotat. *b b b* singularia emissaria cuique utriculo *a*, propri atque in communem canalem excretorium *d*, *c*, suos humores demittentia qui tandem per hujus aperturam *c*, emittantur.

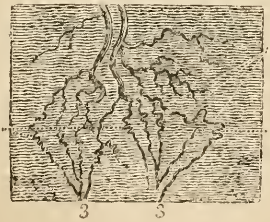
Fig. 2. is a scheme farther to elucidate the opinions of Malpighi. A, an artery entering the portion of a viscus. B, the returning veins. C, the branch of communication betwixt the artery and vein which serves to circulate the blood, and convey a part into the veins. D, another division of the artery, which after various playful meanderings, terminates in the follicule or little glandular bag, E. F, the ducts which receive the secreted fluid from the follicules.

Ruysch studied at Leyden, under Van Horne, and at a very early age attached himself to anatomy and botany. At this time he brought himself into notice by a defence of the professors against one Bilsius, who, although he was learned and acute, had attacked them with all the weapons of a Charlatan. Returning to his native country, he was raised to the professorship of anatomy and botany in Amsterdam. It was here that Ruysch made those discoveries in anatomy, and that wonderful and sudden progress in practical anatomy, which not only raised him above his cotemporaries, but has been the admiration of all since his time. Though new and various methods of preparing the body have been discovered since the time of Ruysch, yet there has been no approach to the elegance with which he displayed the structure of minute parts. It has been said that, while others preserved the horrid features of death, Ruysch preserved the human body in the softness and freshness of life, even to the expression of the features. We must no doubt ascribe some part of this encomium to the exaggeration naturally arising from the novelty of the thing. But as to his superiority in the manner of displaying the minute vessels of delicate parts, and his methods of pre-

serving the parts in liquors, transparent and soft, and so as to float in their natural folds, there can be no doubt. Neither can the minuteness and success of his injections be denied: we have too many occasions in which we must resort to the catalogue of Ruysch's museum for the true anatomy, to doubt his great success, or to question the truth of those encomiums which have been bestowed upon him.

Kings, princes, ambassadors, and great generals, but more than these, all the learned men of the time, crowded to the museum of Ruysch. We must not blame him if, whilst others were merely speculating about the structure of parts, he, surrounded by so princely a museum, should simply have laid open his cabinets, and bid them satisfy themselves whether or not he was right. Ruysch's preparations went to contradict the opinions of Malpighi. His injections pushed more minutely, showed those round bodies which are to be seen in some of the glandular viscera (and which Malpighi took to be little bags into which the secreted fluid was poured) to be merely convoluted arteries. Ruysch taught, that the minute arteries, after making these convolutions, terminated in the beginning of excretory ducts; that there was no substance or apparatus interposed, but that the vessels and ducts were continuous. His opinions being formed upon the strength of more minute preparations, and a superior dexterity of anatomical investigation, few anatomists chose to be outdone, or to acknowledge that they could not see what he saw. This I believe to be one reason of the rapid progress of Ruysch's opinion.

Scheme of Ruysch's opinion.



1 1 The smaller arteries which do not enter into follicules, but are convoluted. 2 2 The appearance of bodies or bags, but which are merely owing to the convolutions and tortuous figure of the arteries before they terminate in the excre-

tory ducts. 3 3 Excretory ducts or vessels formed by the continued extreme branches of the arteries.*

The opinions of Malpighi and Ruysch have held the schools in perpetual controversy; most anatomists however leaning to the authority of Ruysch. There follows these a crowd of French academicians, who, with Boerhaave, may be considered as mere commentators on the original authorities of Malpighi and Ruysch. Some of these argue for secretion by continuous vessels, and contend that the arteries terminate in the excretory ducts; others, that the secretions are made into follicules; and some, as Boerhaave, insist that both are right in their observations, and in the proofs which they have adduced, that secretion is in part performed by continuous vessels, partly by a more intricate glandular apparatus.

I wish to speak with respect of Bichat, yet I cannot help saying that it is edifying in a way which he did not intend, to find him thus expressing himself. Authors have occupied themselves a great deal about the intimate structure of glands. Malpighi admits that they are small bodies of a peculiar nature, and Ruysch has established it that they are entirely vascular. Let us neglect these idle questions, where neither the eye nor experiment can be our guide; let us begin to study anatomy where the structure of organs come under the senses. The rigorous advance of science in this age does not yield to these frivolous hypotheses; and so forth. Thus Bichat does not retrace the steps of the mechanical philosophy, nor enter into the science of hydraulics, nor attach himself to the newer school of chemical physiologists, but in truth gives origin to a new school, *de l'art du cuisinier*. He cooks it; he boils the liver and the kidney, &c. he dries them, boils them again; observes with all possible minuteness and gravity what floats in scum, what remains behind, what gets soft, what hardens by boiling; he smells and tastes; or he roasts the glands with the same ceremony, and still imagines the while he is deeply philosophical.

Of the secretions discharged from the glands it may be sufficient to say, that many of them are destined to be useful to the

* Ruysch's doctrine again was thus opposed: "Ruyschius auget arte sua replendi extensionem vasorum ultra naturalem magnitudinem. Ruyschius arte sua destruit glandulas; dein negat. Ruyschius negat omnes glandulas. Melius est & tutius omnia hæc demonstrare in cadavere recenti." F. Ruysch Epist. ad Vir. Clar. Her. Boerhaave, p. 50.

It may be further observed, that it was not in the mere fact of there being follicules, in which Malpighi and Ruysch differed; for the latter conceded that there were hollow membranes, but contended that these were not glands. The difference of opinion is expressed in the following words of Ruysch; "Adeoque discrepantia inter magnum illum virum et inter me est, quod ille putat humores delabi in glandulas dictas simplicissimas,—ibi foveri mutari: Ego puto, quad arteriæ ultimæ succos faciant, & factos ibi deponant."

further operations of the economy: that they are all liable to be absorbed upon any obstruction to their evacuation; and that, as far as experiments on brutes go, all the animal secretions may be even injected into the circulating fluids without greatly disordering the system.*

The blood carried into the glands has nothing peculiar in its appearance and sensible qualities; the idea once entertained, that the blood issuing from the heart immediately commences a separation of its parts for the several secretions, is quite unsustained; and if it deserves a serious refutation, we have it in the varieties to be observed in the distribution of the arteries to the glands; for a different origin of a secreting artery would in that supposition change the secretion.†

In some of the glands the arteries and veins have a peculiar appearance; they are convoluted, and reflected so curiously, as to have given rise to the idea of their preparing the blood for the secretion; thus in the spermatic chord the vessels have been called the *vasa preparantia*. But this convolution of vessels is for another purpose.

Nothing peculiar has been observed in the distribution of nerves to the glands. They are comparatively small. They have been cut, and still the secretion has gone on. As however most of the higher and distinguishing properties of life reside in the nervous system, so it is reasonable to suppose that not only the various sympathies and sensibilities which the glands possess are derived from the nerves, but also that the secretions which they separate from the general mass of blood, is owing to an influence of life residing in their nerves. An imperfect knowledge of anatomy, and especially of the connections and relations of the nervous system, gives rise to very useless experiments. Is it not strange that experimenters should think that they cut off nervous energy but cutting through the nerve? This is still proceeding upon an oldfashioned opinion, that the brain secretes the nervous spirits, and the nerves dispense them!

Let us be satisfied with knowing a little. The *life* residing in the gland is an agent controlling the affinities. The liver or the kidney secrete bile and urine, not because they have a certain form, but because the affinities of the particles of the blood are controlled by the living principle in the glands to an appointed end, &c. This, while it explains the peculiarity of glands, admits also of a vicarious secretion, that is, the pos-

* Haller, by experiments, proved that several kinds of foreign matter may be conveyed into the circulating blood; and Bichat has made the experiment of injecting all the animal secretions into the veins of brutes.

† *Bichat* has also taken the trouble of examining the blood of the carotid artery, and of the spermatic artery, without being able to observe any difference.

sibility of one gland, or surface, taking upon it the discharge of another.

As the forms of the parts which throw out secretions have an infinite variety, it may be useful in this introductory view to point out these varieties, and their appropriate names.* In the first place, although in general language the term gland implies a secreting body, yet this does not follow from the definition of that word. According to Hippocrates, it is a tumid round body, soft, smooth, and shining. Many such bodies, and which we call glands, have no excretory ducts, and do not secrete a fluid : while most secreting parts admit of no such definition. When, again, we admit the definition of authors who have taught their peculiar opinions regarding their structure, we have a still less admissible description. Thus Malpighi defined a simple gland to be " Membrana cava cum emissario ;" and Ruysch says, " Glandulæ non nullæ componuntur ex sola membrana cava cum emissario sed præcipue ex vasis."

These definitions of glands being optional and uncertain, it is necessary to use names appropriated to the several varieties of form in secreting parts. Indeed the term gland is inadmissible as conveying any knowledge of the minute parts of which the viscera are composed.

We must observe, however, that there is a division of glands still in use into *conglobate* and *conglomerate*. The first implies a gland simple in its form, the latter a gland having the appearance of an assemblage of several glands.† Now there is no gland that has not more or less the appearance which is described by conglomerated ; that is, consisting of several parts, united by cellular membrane ; and the distinction is attended with no advantage.

Acini (the stones of grapes, literally,) form the last subdivision which we observe in the viscera, as in the liver ; they are round bodies, not regularly invested with membranes, and which can be teased out into parcels of minute vessels.‡

Cryptæ (implies cells or cavities) are numerous in the body. We have an example of them in the great intestines.§ Crypta

* The terms acini, cotulæ, cryptæ, folliculi, glandulæ, lacunæ, loculi, utriculi have been almost promiscuously used ; being so many names for bundles, bags, bottles, holes, and partitions.

† As the salivary glands and the pancreas. Farther, the lymphatic glands are generally called conglobate glands, being smooth, and apparently simple in their structure ; but these, when injected, take exactly the appearance which should naturally be described by the term conglomerate, consisting of many little cavities. These lymphatic glands, belonging to a distinct system, require no farther particular definition to distinguish them.

‡ See farther of the acini of the liver for example.

§ Ruych ad Virum Clar. H. Boerhaave, p. 53.

is a soft body, consisting of vessels not completely surrounded with a membrane, and resolvable by boiling or maceration.*

Follicules are little bags appended to the extremity of the ducts, into which the secretion is made, and from which it is evacuated by the ducts.

Lacunæ are little sacs opening largely into the passages, (as in the urethra,) and into which generally mucus is secreted, which lodging there is discharged when matter moves along the passage.

Finally, we have to recollect that every part of the body secretes; that every surface is a secreting surface; that even that surface which is produced by an incision no sooner ceases to bleed than a secretion begins. And that an ulcer in the skin or flesh becomes by habit similar to those organs the peculiar functions of which is to secrete some matter useful in the system. This fact corrects the notions which we should otherwise be apt to receive of the action of secretion from contemplating the more complicated glandular organs.

CHAP. I.

OF THE ABDOMEN IN GENERAL, AND OF THE PERITONEUM.

The abdomen is that division of the body which is betwixt the thorax and pelvis. It is bounded above by the arch of the diaphragm; behind, by the spine; on the sides and forepart by the abdominal muscles; and below, the abdominal viscera are supported by the alæ ilii and the ossa pubis. The abdomen contains the viscera, which are for the purpose of receiving and assimilating the food, and the organs for the secretion of urine. Nature, by the classification of the parts in the great cavities, declares a connection of these parts in function which is never to be lost sight of.

We speak of the cavity of the abdomen; but it is an inaccuracy of language; for there is really no cavity. The parietes of the abdomen, viz. the abdominal muscles and peritoneum, closely embrace the contained viscera. To understand what is meant by the cavity of the abdomen; to understand

* Cryptarum vascula possum docere, sed sunt tam subtilia, ut reptatus non possit distingui: tantum circum affusa rubedo per repletionem videtur." Ruysch ad Her. Boerhaave, p. 77.

the connection of the several viscera, and the manner in which they lie contiguous, while they adhere at certain points only; we must attend to the peritoneum. But, in the first place, let us notice the outward divisions of the belly.

OF THE REGIONS OF THE BELLY.

To give greater accuracy to the description of the seat of the viscera, or, perhaps rather, more strictly to connect the knowledge of the internal parts with the outward marks of the belly, it has been long customary to mark certain arbitrary divisions on its surface, which are called regions.

The EPIGASTRIC REGION is the upper part of the belly, under the point of the sternum, and in the angle made by the cartilages of the ribs. Upon the sides covered by the cartilages of the ribs are the HYPOCHONDRIAC REGIONS, or the right and left hypochondrium. These three regions make the upper division of the abdomen, in which are seated the stomach, liver, spleen, pancreas, duodenum, and part of the arch of the colon. The space surrounding the umbilicus, betwixt the epigastrium and a line drawn from the crest of one os ilii to the other, is the UMBILICAL REGION, and here principally are the small intestines. The HYPOGASTRIC REGION is of course the lowest part of the belly, consisting of the angle betwixt the umbilical region, the spines of the ossa ilii and the pubis. The two lateral spaces betwixt the false ribs and the spine of the os ilii, and behind the line perpendicular to the spine of the ilium, are the LUMBAR REGIONS, or the LOINS: here the kidneys are seated and part of the colon. The hypogastric is divided into three, the pubic in the middle and an inguinal on each side. Draw a circular line round the body from the inferior margin of the ribs; draw another from the superior spines of the ilium across the forepart of the belly; draw a line upwards from the same point of the ilium; the regions are then described.

OF THE PERITONEUM.

THE peritoneum, like all the other membranes of the body, consists of an expansion of dense cellular membrane; yet it is what is called a proper or simple membrane; being a white firm thin contexture of cellular substance, in which no fibre or striated appearance is to be observed.* By its outer surface it adheres to the adipose membrane, on the inside of the ab-

* The meaning of some anatomists, saying, that the peritoneum is a double membrané, will be seen below.

dominal muscles, and to the surface of the several viscera; its inner surface is smooth, and forms no adhesion while the parts are sound and healthy; its outer surface is looser in its texture, and by the splitting of its lamina, it may be traced into the common cellular membrane.

The cellular membrane on the outside of the peritoneum is in some places short, firm, and dense; as on the liver, the spleen, the uterus, and the intestines: but it is longer, lax, and fatty, where it attaches the peritoneum to the muscles and tendons of the abdomem.

The peritoneum has no termination; or it is a sac; yet so curiously is it involved with the viscera, that though we say the viscera are contained in the abdomen, yet, accurately speaking, they are without the peritoneum, and consequently lie not in the abdominal cavity.

Let us follow it in its intricacies, and suppose that we have opened the sac, (that is the cavity of the belly,) we find it first expanded on the lower surface of the diaphragm; and at some of the interstices or perforations of that muscle or its tendon it comes in contact with the pleura, and adheres to it by cellular substance. From the diaphragm the peritoneum is reflected off to the liver, forming the ligaments of that viscus, and, expanded over its surface, it forms its outer membrane. From the diaphragm it is also sent off upon the œsophagus and stomach, and prolonged to the spleen on the left side (as it is to the liver on the right) so as to form the ligaments of the spleen.

The aorta, the great vena cava, the thoracic duct, and the kidneys, are behind the peritoneum; that membrane being stretched before them. But the intestines are also in the same respect behind this general investing membrane; for it is merely reflected from the spine and psoas muscles, and from the great vessels running down upon the spine, so as to involve the intestines and form their outer coat. As it stretches towards the tract of the intestinal canal, it consequently involves the vessels of the intestines in its duplicature, and forms the mesentery.

The peritoneum also lines the abdominal muscles; it is reflected from the diaphragm upon the surface of the transversalis and rectus abdominis muscles. Here it is united to them by a loose adipose membrane, and from the abdominal muscles it is continued upon the inside of the pubes. From the pubes it ascends upon the bladder of urine; descends again behind the bladder; and there, making another reflection to mount over the rectum and form the meso-rectum, it leaves betwixt the rectum and bladder a particular sacculus.

From this detailed description we see that the peritoneum

has no termination; that it is continued from the surface of the diaphragm to that of the abdominal muscles; from that over the bladder and rectum; from the rectum in the whole length of the intestinal canal; and from the intestinal canal up upon the diaphragm. We see then what is meant when it is said that it is a shut sac; we understand by the cavity of the peritoneum merely the inside of this sac; and that when distended with fluid, that fluid is contained betwixt the peritoneum lining the abdominal muscles, and that part of it which invests or forms the outer membrane or coat of the intestines. This fluid, whether collected there by disease or thrown in by experiments, has no natural outlet, nor does it transude in the living body.*

BLOOD-VESSELS OF THE PERITONEUM.

As the peritoneum is a membrane of great extent, and investing a variety of parts, its vessels come from many sources. It receives arteries and veins from the mammary vessels; from the phrenic and epigastric vessels; from the lumbar arteries and veins; and from the ilio-lumbalis, circumflexa ilii, renal and spermatic arteries. It receives nerves from the intercostal, lumbar, and diaphragmatic nerves.

It would appear that disease has given rise to the opinion that the peritoneum has in it many little glands. This is controverted decisively by Morgagni: there are no glandular bodies in the peritoneum.

OF THE USE OF THE PERITONEUM.

The peritoneum serves as a dense and outer coat to the abdominal viscera; conveys the vessels to them, as in the example of the mesentery; and, having its inner surface smooth and lubricated by a watery secretion, it allows the parts to lie in contact, (they being strongly compressed by the surrounding abdominal muscles and diaphragm,) and at the same time allows in the intestinal canal a capacity of motion without friction.

* We not unfrequently find an accurate general description in authors, but some incorrectness in the subordinate detail; which throws back the ideas of the reader into confusion. Such is the enumeration of the holes or perforations of the peritoneum, " pour donner passage à l'œsophage, à la veine-cave," &c. See Anatom. Chirurg. par M. Palfin. We see that there are no such perforations, that the œsophagus never enters into the cavity of the peritoneum, nor does the rectum pass out from its cavity. This was indeed explained by Fernelius in opposition to Galen. See a description of the inflections of the peritoneum by Bartholin.—Specimen Historiæ Anatomicæ Analect. Ob. I.

There is no internal surface or cavity, as it is called, of the living body, which is not moistened by an exudation from the vessels of the surface. Thus it is with the peritoneum. An exhalation from the extreme arteries bedews its surface, and is again taken up by absorbent vessels; so that it does not accumulate in health, nay even fluids poured into the abdominal cavity will be taken up by the absorbents.* When the abdomen is opened in animals alive, or recently killed, as in the shambles, a vapour is seen to exhale from the peritoneum having a peculiar animal odour. Yet we ought not to say that this vapour is collected in the dead body: for before the opening of the peritoneum, or the death of the animal, it is not in a state of vapour, but is condensed into a watery exudation.†

One great use of the peritoneum is to retain the viscera in their place, says Haller; for when it is wounded they escape, and sometimes with a sudden impetus, which makes it difficult to reduce or retain them.‡ But this is not from the want of the embracing of the peritoneum, but from the tendons or muscles which support the peritoneum being cut; for when there is a deficiency in the support given by the abdominal muscles, or their expanded tendons, the peritoneum does not prevent the viscera from being protruded, but easily yields to their forcible protrusion, and forms a sac involving this hernia.

Nor do the processes of the peritoneum, which have received the name of ligaments, nor the mesentery, nor mesocolon, sufficiently resist the prolapsus of the viscera when they have escaped from the pressure of the surrounding muscles. Sufficient examples of this we have in hernia of the intestines, in which the mesentery is greatly elongated, or in the displacement of the stomach, or in the prolapsus and procedentia uteri.

The peritoneum which forms the sac of hernia retains little elasticity, and does not shrink into the belly when freed from the outer adhesions; but the general peritoneum will allow great distention, as in ascites, and quickly contract to its former dimensions on the evacuation of the fluid; and so that

* See Nuck Sialograph. c. ii. p. 27.
Qua copia in Statu secundum naturam secernatur dictu difficile est: ad uncias certe collecta aquula in sani hominis abdomine reperitur. (Kaawn, 543.) In homine, cui sponte abdomen sub umbilico ruptum erat ad quinque & sex libras de die effluebat. (Journ. de Med. 1757. M. Aug. ut denique 800 libr. effluxerent.) This, however, proves nothing of the nature or quantity of the secretion: this has probably been an inflammation and abscess of the peritoneum, which, we have seen, pours out such a quantity of fluid, thin and serous, as quickly to drop through the bed-clothes upon the floor.

† This vapour I have seen arising from the intestines of the human body during the operation for hernia; and also when the omentum and intestines have escaped in consequence of a wound of the belly.

‡ Element. Physiol. tom. ii. p. 380.

part of the membrane which invests the stomach and intestines, the bladder of urine and gall-bladder, has considerable elasticity, since it suffers these parts to be distended and again returns to its former dimensions.

The consideration of the insufficiency of the peritoneum to retain the viscera leads us to attend to a circumstance of the greatest importance connected with the viscera of the belly. The abdomen is every where (except towards the spine) surrounded by muscles. Above we see the diaphragm; before, and to the sides, the abdominal muscles; and even below, the parts in the pelvis are surrounded and compressed by the levator ani, in such a manner that the whole of the viscera suffer a continual pressure. This pressure upon the viscera appears to be uniform and constant, notwithstanding the alternate action of the abdominal muscles and diaphragm as muscles of respiration: but it must be occasionally very violent during exertions; in pulling, for example, or in straining, as a sailor must do in working of the great guns, or when pulling at the oar, or when balancing himself upon his belly over the yard-arm. And indeed by such violent and general compression of the viscera of the belly, ruptures are sometimes produced, of the worst kind, and followed by an immediate train of urgent symptoms.

The viscera having in general delicate outer coats, and no ligaments capable of supporting them, and being very vascular, require the support of this pressure of the surrounding muscles; and the great venous trunks which take their course through the abdomen are in a particular manner indebted to the pressure of the abdominal parietes. We must recollect also the bad consequences which result from the sudden relaxation of the abdomen; as in women after delivery, or in consequence of withdrawing the waters of ascites without due compression of the belly; languor, faintness, and even death, are sometimes produced, apparently by the balance of the vascular system being destroyed.

Some good authors in former times have described the peritoneum as a double membrane.* This was no farther a mistake than as they considered the cellular membrane, which lies without the peritoneum, as a part of it. It is necessary to recollect this in order to understand the meaning of their calling the sheath of the cellular membrane, which accompanies the vessels passing out from the abdomen, productions of the peritoneum. The vaginal productions of the peritoneum are the sheaths of the common cellular substance which accom-

* See Anat. Chirug. par M. Palfin. tom. ii. p. 35. and note *a*.

pany the aorta and œsophagus into the posterior mediastinum; or which give a bed to the spermatic vessels, or passing under Poupart's ligament accompany the vessels of the thigh. They are improperly termed productions of the peritoneum.

The proper productions or prolongations of the peritoneum are of a very different kind; they are the ligaments and plicæ, the mesentery, mesocolon, omenta.

OF THE LIGAMENTS AND FOLDS FORMED BY THE PERITONEUM.

There are certain ligaments and plicæ formed by the peritoneum, which to enumerate will carry us again over all the extent of its surface. When this membrane is reflected off to the œsophagus from the diaphragm, it forms 1. the *ligamentum dextrum ventriculi;* and 2. the *vinculum œsophagi*. In the same manner is formed, 3. the *ligamentum inter œsophagum et lienem*, which we may trace into the omentum majus, presently to be described. From the spleen we may trace the membrane into, 4. the *plica renalis* and *capsularis*: 5. another *plica* or duplicature, may be traced from the kidney to the colon, and on the right side, 6. the *plica duodeno-renalis*, viz. from the kidney to the duodenum. When we turn up the liver, we are led to observe the five ligaments to that viscus, to be described in their proper place, and from the liver stretching to the kidney we find the 7. *ligamentum hepatico-renale* still tracing the convolutions of the intestines, and following the *mesentery* or ligament of the small intestines, into the *mesocolon*, or ligament of the great intestines, and the *mesorectum* or process of the peritoneum to the rectum; we there see the 8. *plica semilunaris*, which is before the rectum, and behind the bladder of urine.

The young anatomist ought to trace all these processes of the peritoneum, both to comprehend the great extent of surface exhibited by this membrane, and the relations of the viscera to each other.

OF THE OMENTA.

The omenta are considered as secondary processes of the peritoneum, because they are not formed by the peritoneum reflected off from the spine upon the intestines, as the mesentery is,—it being a primary process; but they are reflected from the surface of the stomach and intestines. Anatomists distinguish the *omentum majus*, or colico-gastricum: the *omen-*

tum minus, or hepatico-gastricum ; *omentum colicum*, dextrum and sinistrum ; and, lastly, the *appendices epiploïca.*

The OMENTUM, or EPIPLOÖN, meaning thereby the great omentum, is a floating membrane of extreme delicacy, expanded over the surface of the small intestines, and attached to the great arch of the stomach and intestinum colon. Although this membrane be of extreme delicacy and transparency in the young subject,* yet it is much loaded with fat, and appears transparent in the interstices only ; and in advanced age it loses much of its delicacy, and acquires a degree of diseased consolidation or firmness, and is often irregularly collected into masses, or adheres preternaturally to some of the viscera.

The omentum majus hangs suspended from the cellular connection betwixt the arch of the stomach and the great transverse arch of the colon; or rather it forms that connection betwixt the stomach and colon. It consists of two membranes, or is as a sac collapsed and hanging from the stomach and colon,† one of the sides being the peritoneum reflected off from the œsophagus and along all the great arch of the stomach, and the other that which comes from the arch of the colon. And further, each of these lamina may be supposed to consist of two lamina ; for example, where the omentum is formed by the meeting of the peritoneum from the lower and upper surfaces of the stomach ; these two uniting, form the upper lamina : and where the lower layer of the omentum comes off from the colon, it is also formed by the peritoneum reflected in the same manner from both sides of that intestine ; so with some truth the omentum is supposed to consist of four lamina of membranes of extreme tenuity : but these four layers cannot be demonstrated. The great omentum extends from the bosom of the spleen transversely until it terminates on the right side of the arch of the colon, where the omentum colicum begins.

The great omentum varies considerably in extent. In a child it is short ; in the adult further extended over the viscera : sometimes it reaches only to the umbilicus ; sometimes it is allowed to extend its margin into the pelvis, so that in old people it is very apt to form a part of the contents of hernia ; often it is wasted and shrunk ; sometimes collected into masses leaving the surface of the intestines.

My reader must now find his way into the *marsupium*, or

* Præterea tenerrimas esse ut nulla membranarum humanarum, retina oculi excepta, æque sit tenera. Haller, vol. vi. lib. 20. § 1. par. 12.

While its delicacy is remarkable in the young subject, the retiform vessels (vid. Ruysch. Ther. II. Q. V. Spegil. LVIII. &c.) have the fat accumulated in their tract as it were thrown up by them to a side ; but often the fat increasing obscures the vessels

† Marsupium the common term.—See Winslow. IV. § 352.

purse of the omentum, viz. the *porta omenti*, the celebrated foramen of Winslow. It will be found to be a slit betwixt the ligamentum hepatico-colicum and hepatico-duodenalis, being under the biliary vessels and vena portæ. Upon blowing into this opening, in a young subject, three omenta are distended viz. the *omentum hepatico-gastricum*, the *colico-gastricum*, and the *colicum*.

This opening serves as a communication betwixt the cavities of the omentum and the general peritoneal cavity; but I am inclined to think it is very frequently destroyed by adhesions.* As this opening points towards the right side, Dr. Monro thinks it a sufficient reason for introducing the trocar on the right side in the operation of tapping for ascites: (contrary to the usual caution of avoiding the liver, which is so often diseased in this case,) by operating on the left side he thinks the water will not be allowed to flow from the sac of the omentum. It appears to me that it will flow equally well from whatever point of the belly the water is drawn.

OF THE OMENTUM MINUS, OR HEPATICO-GASTRICUM.

THIS is a membrane of the nature of that last mentioned, but in general less loaded with fat. It is extended from the liver to the lesser arch of the stomach. It passes off from the lower surface of the liver at the transverse fossa; from the fossa ductus venosi; invests the lobulus spigellii; involves the branches of the cæliac artery; and is extended to the lesser curvature of the stomach and the upper part of the duodenum.†

OMENTUM COLICUM.

THIS is a continuation of the great omentum upon the right side of the great arch of the colon, where it rises from the caput coli; but it seldom extends its origin from the colon the length of the caput coli. It is inflated with the great omentum.

APPENDICES EPIPLOICÆ, OR OMENTULA INTESTINI GRASSI.

THESE are little fatty and membranous processes which hang pendulous from the surface of the colon: they are of

* Winslow, Duverney, and Haller.

† "Macilentius es, et vasa habet minora." Winslow. Haller. Indeed it seems rather to answer the general purpose of a cellular membrane conveying vessels, than the purposes of the omentum majus.

the same texture and use with the greater omentum and right colic omentum.

We have mentioned that the omenta are double reflections from the peritoneum, and consequently they may be inflated so as to demonstrate them to be perfect sacs. To do this it is not required to puncture any part of them, for by the natural opening just described, the whole may be inflated in a young subject, and in a healthy state of the viscera.

There is a considerable variety in the form of the omentum of animals,* but still they seem to show the same provision of involving the intestines, filling up the inequalities which arise from the rounded forms of the viscera, and still further lubricating and giving mobility to the intestines.† The surface of the omentum, however, seems merely to furnish a fluid exudation like the general surface of the peritoneum; and the idea which has been entertained of the oil or fat exuding is not true.‡

The use assigned to the omentum of being subservient to the function of the liver is deservedly neglected.§

CHAP. II.

OF THE VISCERA OF THE ABDOMEN.

Having understood the nature of the general investing membrane of the abdomen, and what is meant by its cavity and its processes, we take a general survey of the economy of the viscera, before entering upon the minute structure of the parts individually.

The contents of the abdomen are thus enumerated in elementary works on anatomy.

1. The membranous viscera, viz. the stomach, the small and great intestines, the gall-bladder, mesentery, the mesocolon, and ligamentous processes, and the omenta.

* Haller Element. Physiol. tom. vi. lib. xx. § 2 and 3.

† We must not suppose because a madman stabs himself in the belly, and there is afterwards found coalition of the intestines to the wounds, the omentum has not done its office, (see Boerhavii Prelectiones, vol. i. § 45.) no more can we give credit to the tale told by Galen (De Usu Partium, l. iv. c. 9.) of the gladiator who lost part of the omentum, and ever after had a coldness in his guts! at least we cut out a great part of the omentum from a man without any such sensation being the consequence now-a-days.

‡ "Et dum halitu pingui & ipsa obungit & peritoneum." Hal. loc. cit. Boerhaave, &c. Morgagni Adversar. III. Animad. VI.

§ Viz. by supplying a gross oily matter to the venæ portæ.

2. The SOLID VISCERA, viz. The liver, spleen, pancreas, the kidneys, and renal capsules, the mesenteric glands; but a natural order in the arrangement of these viscera is to be preferred.

The organs destined to receive the food, and to perform the first of those changes upon it, which fit it (after a due succession of actions) for becoming a component part of the living body, are the stomach and intestines primarily; the glandular viscera, the liver, pancreas, and the spleen, are subservient or secondary organs. I have been accustomed in my lectures to divide these parts into those which have action and motion, and those which are quiescent or possessed of no power of contraction. Thus the stomach, intestines, gall-bladder, and bladder of urine (though this belongs to the pelvis) have muscular coats, and the power of contracting their cavities; while the liver, spleen, pancreas, and kidneys, have no muscularity but in their vessels and excretory ducts.

This division of the viscera may lead to important distinctions in pathology. During inflammation, it is observed, that though the parts possessing a power of contraction may sometimes lie inactive without pain, yet in those parts when roused to action there is excruciating pain. On the other hand, it often happens that the glandular and solid viscera are the seat of long continued disease, which is attended only with a dull or low degree of pain; while the anatomist is often struck upon examining the body after death with the wide ravages of the disease.

WE divide the intestinal canal into three parts; the stomach, the small intestines, the great intestines. The small intestines are subdivided into the duodenum, jejunum, and ileon. The great intestines are subdivided into the cæcum, colon, and rectum. The stomach is the seat of the digestive process: in the duodenum the food receives the addition of the secretions from the liver and pancreas, and is still further changed; in the long tract of the jejunum and ileon the nutritious part is absorbed; and in the great intestines the foul sediment becoming fæces is carried slowly forward, suffers a further absorption of fluid, lodges in the lower part of the colon, and then in the rectum or last division of the canal.

From this view it is apparent that as each division of the intestinal canal is marked by some peculiarity in its use or function, we must carefully examine their minute structure as individual parts, at the same time that we do not allow ourselves to forget the universal connection, the integrity of the circle

of actions, and the economy as a whole. With this intention, following the course of the food, we treat first of the œsophagus.

SECTION I.

OF THE ŒSOPHAGUS.

The œsophagus or gullet is a cylindrical muscular tube, which conveys the food to the stomach. It is continued from the pharynx down behind the larynx and trachea and close before the spine, and continuing its course in the back part of the thorax, it perforates the diaphragm, and expands into the upper orifice of the stomach.

Although with many authors I call it a cylindrical tube, and it may take this form when dissected from the body and inflated, yet during life it lies collapsed with its inner membrane in close contact, and it transmits the morsel only by the continued succession of the contraction of its fleshy coat.

The upper part of this tube is called the pharynx. It may be described as being expanded like a funnel; it is attached to the occipital bone, pterygoid processes of the sphenoid bone, and jaw-bones; and further down it is kept expanded upon the horns or processes of the os hyoides. This bag is very fleshy, being surrounded with muscular fibres, which take their origin from the neighbouring fixed points; as the styloid process, the horns of the os hyoides, the thyroid cartilage; by which it is enabled to grasp and contract upon the morsel when it has been thrust by the tongue behind the isthmus faucium. This strong tissue of muscular fibres which surrounds the pharynx, is continued down upon the œsophagus in the form of a sheath, which has been called tunica vaginalis.

I believe we can with propriety enumerate no more than two proper coats of the œsophagus; its muscular and internal coat: for that which is sometimes considered as the outer coat, is only the adventitious cellular membrane, and the nervous coat is merely cellular tissue connecting the muscular and inner coat.

The MUSCULAR COAT of the œsophagus greatly surpasses in strength and in the coarseness of its fibres any part of the whole tract of the intestinal canal. There may be very distinctly observed in it two layers of fibres; an external one consisting of strong longitudinal fibres, and an internal one of circular fibres. These lamina of fibres are more easily separated

from each other than those in any other part of the body.* But an idea is entertained that the one set of fibres, the circular and internal ones, are for contracting the tube, and the outer ones for elongating and relaxing it. I believe on the other hand, that they contract together, conducing to one end, deglutition.†

What is called the TUNICA NERVEA is the cellular connection betwixt the muscular and inner coat, and is very lax, insomuch that the muscular coat and the inner coat are like two distinct tubes, the one contained within the other, and but slightly attached. This appearance is presented particularly when the œsophagus is cut across.

The INNER COAT of the œsophagus is soft and glandular; villi are described as being distinguishable on its surface, and it is invested with a very delicate cuticle which dulls the acute sensibility, and prevents pain in swallowing. It in every respect resembles the lining membrane of the mouth. The power, however, which the œsophagus seems to possess of resisting heat depends not on the insensibility bestowed by the cuticle, but is owing to the rapid descent of the hot solids or liquids swallowed; for when they happen to be detained in the gullet they produce a very intolerable pain. This inner coat has an exhaling surface, like the rest of the body, with particular glands to secrete and pour out that mucus which lubricates the passage for the food. These glands suffer ulceration and scirrhous hardening, and are a terrible cause of obstruction to swallowing. The inner coat is capable of a great degree of distention, but it is not very elastic, or at least contraction of the muscular coat throws it into longitudinal folds, or plicæ.

In the neck the œsophagus lies betwixt the cervical vertebræ and the trachea, but is at the same time in a small degree towards the left side. At the bottom of the neck it perforates the membranous fascia, and enters the thorax. Here the surgeon should take good heed of the relation of the tube to the fascia, for I have seen a stricture imagined to be present from an instrument resting on this membranous connection. When the œsophagus has entered the thorax it descends retiring a little backwards at the same time, and passing behind the bifurcation of the trachea and the arch of the aorta, when it

* It appears that the œsophagus can be ruptured in two ways: across, by the tearing of the longitudinal fibres; and longitudinally, by the separation of the longitudinal fibres. This, though a rare accident, takes place in violent vomiting or straining to vomit; and, in the first instance, the tearing across of the œsophagus seems to be the effect of the action of the diaphragm on the œsophagus. By this accident the fluids of the stomach are poured into the cavity of the thorax.

† See farther of the muscular coat of the intestines. "It was at one time supposed that the muscular fibres of the œsophagus had a spiral direction." See Verheyn, and Morgan. Adversar. iii.

descends farther upon the dorsal vertebræ, it lies rather to the left side; escaped from the aorta, it lies on the right side of it, and as it passes further down it gets more and more before the aorta. This is sufficiently apparent when we attend to the relation of the perforations in the diaphragm for transmitting the aorta and the œsophagus.

Behind the œsophagus, in the thorax, there are one or two lymphatic glands, which were understood by Vesalius to belong to the œsophagus. What deceived him is an appearance to be observed in these glands. The lymphatics, or the small branches of veins, are generally filled with a black matter, which, extending to the coats of the œsophagus, resemble very much the ducts of the glands going to open into the œsophagus. These glands in the posterior mediastinum are sometimes diseased and enlarged so as to compress the œsophagus, and to cause so permanent an obstruction of deglutition as to occasion death.

The inner coat of the œsophagus shows so very different a texture from that of the stomach, and this difference is marked by so very abrupt a line, as sufficiently to indicate that the fluids poured out from the œsophagus are very distinct from those of the stomach, and have probably no digestive property.

SECTION II.

OF THE STOMACH.

The stomach is that capacious membranous bag into which the œsophagus delivers the food, and in it is performed the process of digestion. The food of animals is of various kinds, and the form and structure of the stomach varies according to the nature of the food. Animal food affords that rich aliment in a state nearly prepared for supplying the deficiencies of the living system. In such animals as live on flesh the stomach is simple in its form, and possesses little muscular property. On the contrary, vegetable food has a smaller proportion of nutritious matter in it, and requiring for its separation a more complicated and tedious process of maceration, trituration, and digestion. Therefore in brutes living on vegetable matters we observe a more intricate system of vessels or reservoirs, all separating and preparing the food for the operation of the digesting stomach or true stomach. The human stomach is simple compared with the stomach of the herbivo-

rous animals, but more curiously guarded to retain and fully to operate upon the food than the carnivorous stomach.

Since I am entering on this subject I may add, that the length and intricacies of the intestines hold always a relation to the form of the stomach. If the food of an animal be of difficult digestion, and offer little nutriment, as it requires a complicated stomach, so will it require to be carried through the intestines long and intricate, that opportunity may be given for the whole nutritious matter to be absorbed and turned to use. But if, on the contrary, the food be rich in nutritious matter, the intestines will be shorter, more direct, and have less of that apparatus intended to delay the course of the contents.

Seat, Form, Displacement of the Stomach.

The stomach lies under the margin of the ribs of the left side, and chiefly in the left hypochondrium. Its greater extremity is on the left side, in contact with the diaphragm; but towards the right, the shelving edge of the left lobe of the liver is betwixt it and the diaphragm. On the lower part it is, by the mesocolon and arch of the colon, divided from the small intestines; and to the greater extremity the spleen is attached by vessels, and by the loose intertexture of the omentum. The stomach may be said to be a conical sac; the extremities of which being made to approach each other, gives it the curve of a hunter's horn, and gives occasion to the anatomist, in strict description, to remark these parts; the SUPERIOR or CARDIAC orifice, into which the œsophagus expands; the LOWER or PYLORIC orifice, which leads into the duodenum; the LESSER and GREATER CURVATURES of the stomach; and the great bag towards the left where the spleen is attached.

The lesser curvature of the stomach extends from betwixt the two orifices; includes in its embrace, the spine, the aorta, and the small central lobe of the liver, while there is attached to it the lesser omentum. The greater curvature of the stomach is the outline of its distended belly, which rises above the arch of the colon, and is marked by the course of the gastro-epiploic vessels.

In the fœtus, the stomach lies more perpendicular than transverse. In the adult, when the stomach is distended, the lower orifice is nearly on a level with the upper one; but when the stomach is allowed to subside, it falls considerably lower; so that whilst the stomach lies across the abdomen it is also tending obliquely downwards. The ensiform cartilage will be

found to present to the middle of the stomach ; and the lower orifice, when in its natural situation, is opposite to the fossa umbilicalis of the liver ; the upper orifice is kept constantly in one place from the stricter connection of the œsophagus with the diaphragm.

Both orifices of the stomach present backward, especially the upper one, while the lower one is pointed backward and downward. By the distention of the stomach the great arch is extended, the orifices are directed more backward and towards each other, and especially the greater extremity draws upon the œsophagus. By these means I conceive that there is sometimes produced a difficulty of the stomach discharging its contents when greatly distended, the orifices being in a great measure turned from the œsophagus and duodenum.

The stomach being liable to frequent varieties in its degree of distention, the natural relation of parts must frequently be altered. It ought to be particularly recollected, that in the living body the stomach is supported and bound up by the intestines; so that the great curve presents: and the broad anterior surface which the stomach presents in the dead body is turned directly upward, and the inferior downward.* By the collapsing of the stomach and the consequent falling down of the liver, some have explained the sensation of hunger, conceiving that the uneasy sensation proceeds from the liver being allowed to hang upon the broad ligament.† From the great simplicity of mechanical explanation physicians have eagerly indulged in them, but it will in general be found, that when they are applied to the explanation of the phenomena of a living body they lead to erroneous ideas.

In describing the human stomach as a conical bag curved, I speak of what we shall commonly observe in the dead body. But sometimes I have found the stomach divided into two sacs, and more frequently have I seen a contraction in the centre of the stomach from muscular action. The two last subjects for public demonstration, I found divided into two sacs. *Riolan* demonstrated this in 1642. *Schneider* and *Dionis* have given us such instances, and *Morgagni* has expressed an opinion that these were not divisions, but only contractions of the stomach. In fact, we meet with a permanent, as well as an occasional, form of the human stomach, in which there is a division into two sacs.

* Thus the gastro-epiploic artery presents directly forward. It has been wounded, and bled both into the stomach and outwardly. I should conceive it possible in such a case to tie the artery.

† Winslow.

But it is to Sir Everard Home we owe the knowledge of the fact, that the stomach is divided into two parts by muscular contraction. He is of opinion that the cardiac and pyloric portions, thus divided, perform distinct offices.

OF THE COATS OF THE STOMACH.

The coats or membranes forming the stomach are the outer, the muscular, the nervous or vascular, the villous, and the three cellular coats. For some of these subdivisions, however, I see no use, nor are they authorized by the natural appearance of the coats of the stomach. When there is a distinction in texture, structure, of function, and where these lamina can be separated, we shall consider them as coats; but a mere intermediate tissue of vessels, or the connecting cellular membrane, are improperly considered as distinct tunics.

First coat.—From what has been already said of the peritoneum, it will readily be allowed that the outer coat of the stomach is formed by the peritoneum; a coat common to all intestines. Were this not sufficiently evident in itself, it might be ascertained by dissecting the peritoneum from the cardiac orifice of the stomach, where it will be found reflected from the diaphragm. This coat is firm, simple in its texture, having no apparent fibrous texture, and smooth on its outer surface, with many minute vessels. Under the peritoneal coat is the first cellular coat, being in fact a short cellular tissue betwixt the peritoneal coat and the muscular coat.

Muscular coat.—The muscular coat of the stomach consists chiefly of several lamina of fibres; less distinct however than those of the œsophagus, or, in other words, more loosely and irregularly connected.*

These muscular fibres of the stomach do not run in an uninterrupted course, but split, rejoin, and form a kind of retiform texture, through which the coats beneath are at intervals discernible. This structure would appear to bestow a greater power of contraction on the stomach. The strong longitudinal fibres which are seen upon the œsophagus form the outer stratum of the muscular coat of the stomach, and they extend from the œsophagus and cardiac orifice in a stellated form along the upper curvature, and downward upon the great end or sacculus ventriculi. Then we have to observe a set of cir-

* The most general opinion is, that there are three layers of fibres in the stomach. Some describe an external longitudinal series; a middle transverse stratum: and again the internal fibres running longitudinally. See Galeati Acad. de Bologne.

cular fibres, which forming rings upon the great end, extend over all the stomach, like the circular fibres of the arteries. These fibres do not each encircle the stomach entirely, but while their general direction is circular, they are so interwoven that no one fasciculus can be followed to a great extent. These are called the TRANSVERSE FIBRES or STRATUM; while the deepest stratum consists of the continued circular fibres of the œsophagus. These last fibres are strong upon the cardiac orifice, and may be presumed to form a kind of sphincter; but they diminish as they are remote from the superior orifice. The lower or pyloric orifice of the stomach, however, is more carefully guarded by muscular fibres; having in the duplicature of the inner coats a distinct circular ring of muscular fibres.

The cellular tissue, being intermingled with the muscular fibres, connects and strengthens them, and gives the appearance of little white lines interwoven with the muscular fibres, and which some have described as small tendons.* There is also to be observed a broad ligamentous band on the two flat surfaces of the stomach towards the pylorus. They are like the bands of the colon, but not nearly so strong or evident. They are formed by the denser nature of the cellular tissue, and more intimate union betwixt the first and second coats.

OF THE ACTION OF THE MUSCULAR COAT.

Upon considering the weakness of the muscular fibres of the stomach, and the membranous nature of the whole coats, it appears that the general action of the stomach is slow, regular, and by no means a forcible contraction; not an apparatus for triturating the food, and merely giving motion to its contents. But regarding the extreme sensibility of the stomach, and the gradual and regular succession of action, much will be found that is worthy of attention.† It should seem that the morsel is sent down into the œsophagus by a succession of actions, preceded by a perfect relaxation; and that when the food arrives at the superior orifice of the stomach, by the same relaxation preceding the contraction, the muscular fibres of the upper part of the stomach yield and receive the food compressed by the œsophagus. Attending to the form of the stomach, we see a provision for the reception of the food into the great sacculated fundus on the left extremity. And here we shall find that there is a greater profusion of vessels for the secretion of the juices of the stomach, and a

* See Winslow, sect. viii. p. 57.

† See Haller's Experiments. *Opera minora,* Ventriculus Motus peristalticus.

set of the muscular fibres, probably relaxing and yielding to receive the food, and excited to action only when the process of digestion has been in part or entirely accomplished. Often, on dissection, I see the sac or left extremity of the stomach distended, when towards the right extremity it is like the intestine in form. We have proof, that when the food has remained the usual time in the great sac of the stomach, and comes in succession to be presented at the lower orifice, if the stomach be healthy, and the change upon the food perfect, the lower orifice is relaxed, and yields to the contraction of the muscular fibres of the stomach, and the contents of the stomach are passed into the duodenum: but if the food has been of an indigestible nature, it is rejected. The pyloric fibres refuse the necessary relaxation, and by the unnatural excitement an antiperistaltic motion is produced, and the matter is again thrown into the great end of the stomach, or rejected by vomiting.* There is in the natural action of the stomach a stimulus, followed by a regular succession of motion in its fibres, conveying the contents from the upper to the lower orifice of the stomach. Of this excitement and action we are not conscious; but when the action is disordered by an unusual excitement, the lower orifice is not unlocked, the action becomes violent (the reverse of what naturally takes place,) and pain or uneasy feelings are produced. Upon this principle may be explained the nausea and vomiting which take place at certain times after eating, when balls or concretions are lodged in the stomach. While the food lies in the greater extremity or in the body of the stomach, and the ball or concretion with it, there is no great excitement; but when it has suffered the necessary change, and is approaching to the pyloric orifice, this part, being as it were a guard upon the intestines, is suddenly excited, vomiting is produced, and the ball is thrown into its old place in the sacculus or great end.

An attempt has been made to distinguish the affections of the stomach according as they proceed from the vitiated secretion, or the disordered muscular action. For example, it has been said, if there is pain when the stomach is empty, then is it owing to the secretions of the stomach hurting the coat; if there be pain when the stomach is full, or at regular periods after taking food, then is it proceeding from disordered muscular action. This is settling the whole difficulty on too easy terms. The function of the muscular fibre and of the secreting vessels are not thus distinct. The motion of the stomach itself and the secretions into it are actions conducing to a general result,

* It would seem that the upper orifice of the stomach has a power of contraction on unusual stimulus applied. Haller loc. cit. Exp. ccciii.

and nature has secured the end by combining the means ; and vitiated fluids poured into the stomach even by its own vessels, are attended with irregular spasmodic pains.

This great sensibility, producing effects almost like intelligence, is apparent in the more common disorders of the stomach. We shall find the meteorismus ventriculi (the great distention of the stomach by flatus) existing for weeks, and yet the food passing in regular course through its orifices. We shall find very frequently food of difficult digestion lying in the stomach and oppressing its functions for days, while food more recently received may have undergone the actual changes, and have passed through the pylorus into the duodenum.

Owing to the same slow and successive action of the stomach, it often happens that ulceration and scirrhous pylorus, or other obstruction of the lower orifice of the stomach, is attended with pain, nausea and vomiting, only at stated intervals after taking food ; *i. e.* at the time in which the food should be sent into the intestines in the natural course of action.

The muscular fibres of the stomach are excited by stimuli, applied, not to their substance, but to the contiguous coats ; and betwixt the delicate surface of the inner coat and the muscular fibres there is the strictest sympathy and connection. The same connection holds in a less intimate degree betwixt the outer coat and the muscular fibres ; for when a part on the surface of the stomach of a living animal is touched with acid or stimulating fluids, the part contracts.* The stomach is considered as less irritable than the intestines, because it is alleged that a stronger dose of a medicine is required to prove emetic than to act as a purgative : but we ought to consider that the action thus excited in the intestines is merely an acceleration of their secretions ; but vomiting is the interruption of the usual action, requiring such a violent excitement as to invert the natural action.

But there is something more than this ; as the function of the stomach differs from that of the intestines, so may the quickness of their action. Thus in the stomach a gradual change is to be produced upon the food, requiring time and a slow degree of motion ; but in the intestines there is a greater agitation of their contents, and a quicker action of their coats, to bring the fluids into more general contact with the absorbing surface, and to give greater activity probably to the absorption by the lacteals. I am inclined to think that the stomach

* "In ea sede quà tangitur, contrahitur, sulcusque profundus nascitur, et rugæ ; cibusque aliquando propellitur ut à sede : contracta fugiat. Minùs tamen quam intestina ventriculus irritabilis est : hinc emetica fortiora necesse est purgantibus."—Haller.

is the most irritable part of the body, and susceptible of the most minute distinctions in the nature of the stimuli applied to it. The phenomena of the living animal, and experiments in those recently killed, sufficiently prove the contractile powers of the two orifices. Experiments have been made which show the powers both of the cardiac and of the pyloric orifices, in retaining the contents of the stomach after the œsophagus and duodenum have been cut across. The stomach of a rabbit has been squeezed in the hand after cutting the duodenum, without any of its contents having escaped;* and in similar experiments, the finger being introduced into the lower orifice of the stomach of an animal yet warm, the fibres of the pylorus were found to contract strongly upon it. Upon forcibly compressing the stomach, the food will be made to pass into the œsophagus much more readily than into the duodenum; which is another proof how necessary the natural series of actions is to the relaxation of the pylorus.

Rumination.—As it is found that some individuals ruminate, and that even such a habit may be acquired, it must be right to say a few words on this subject.—In the ruminating quadrupeds the food passes into the paunch. The paunch consists of a larger and smaller cavity, and from the lesser cavity the food is regurgitated into the mouth, to suffer mastication. When a second time swallowed, it is let into the third cavity, which is the true digesting stomach, and from the third it passes into the fourth cavity, and from that into the intestines. The human stomach cannot perform an operation so complicated as this. But the different directions which the food takes in the stomach of the ruminant animals in their instructive motions, closing or adjusting the slits of the œsophagus, or the openings of the several bags, proves to us that many silent and curious operations may be going forward even in the human stomach. Something we might suppose would be learned from the feelings of such men as chew the cud; but it happens that the best recorded instance occurred in one, a mere brute in intellect.† Here the morsel was brought up from the stomach by a very slight effort; it was chewed and swallowed: after a pause another morsel was brought up, and underwent the same process. This being swallowed, he ate his food voraciously and without chewing. There is no history of dissection on record except on the authority of Fabri-

* See a paper in the 3d vol. of Sandifort, Thes.
An excellent plate of the Pylorus is given with this Dissertation.—*Morgagni* Adversar. III. IV. de Ventriculi Struct.

† By Sir Everard Home.

cius ab Aquapendente, who found the œsophagus remarkably muscular.

It is probable in the rumination of man that the great left extremity of the stomach serves the purpose of a temporary receptacle, and that in the first process it is not admitted generally to the cavity of the stomach, or towards the pyloric extremity.

Of vomiting.—When there is an unusual or unnatural irritation on the stomach, or when it is violently stimulated or opposed in its natural course of action, the motion becomes inverted; and drawing by sympathy other muscles to its aid, the contents of the stomach are evacuated by vomiting. Thus where the food takes changes inconsistent with healthy digestion; or when solid matters lodge in the stomach; or when secretions of the duodenum pass into the stomach, or unusual actions are propagated backwards upon the stomach from the upper portion of the canal; or when emetics are taken which are unusual stimuli; or when there is inflammation in the stomach, which from giving greater sensibility, produces the same effect with more violent stimuli; or when the coats are corroded or ulcerated;—vomiting is produced. That vomiting may be produced by the inverted motion of the stomach and œsophagus alone, is apparent from experiments upon living animals, where the abdominal muscles are laid open, and from cases in which the stomach has lain in the thorax, and yet been excited to active vomiting.* Again, it is equally evident that, when the stomach is excited to vomiting, there is consent of the abdominal muscles, by which they are brought into violent and spasmodic action; not alternating in their action, as in the motion of respiration, but acting synchronously, so as greatly to assist in compressing the stomach: but at the same time, the action of these muscles, however forcible their contraction, cannot alone cause vomiting; nor has this action any tendency to produce such an effect on other occasions, in which the utmost contraction of the diaphragm and abdominal muscles is required to the compression of the viscera. Many have conceived that vomiting is entirely the effect of the action of the abdominal muscles and diaphragm. Such, for example, has been the opinion not only of J. Hunter, but of Duverney, and of M. Chirac in Hist. de l'Acad. de Sciences, 1700. M. Littre opposed this notion, and contended before the Academy, that the contraction of the diaphragm was the principal cause of vomiting. M. Lieutaud in 1752 supported the idea that vomiting is the effect of the action of the stomach. He

* See Wepfer de Cicuta Aquatica, p. 68.—Sauvage's Vomitus.

found, upon dissection, in a patient whose stomach had resisted every kind of emetic, that it was greatly distended and become insensible; and concluded that the want of action in the stomach, and consequent loss of the power of vomiting, was a strong proof of the action being the effect of the contraction of the stomach only. There are other more curious instances of disease of the stomach preventing the muscular contraction in any violent degree, and consequently the absence of the usual symptom of vomiting:—an instance of this kind will be seen in Dr. Stark's work. In my Museum I have a preparation of a stomach, in which the walls had become so thick that they could no longer suffer contraction by the muscular fibres; the consequence of which was, that although the inner coat of the stomach was in a raw and ulcerated state, there was no active vomiting.

There is a very curious experiment by M. Magendie which has much puzzled men's minds. He cut out the stomach of a large dog, and substituted in its place a bladder which he fastened to the œsophagus, and having excited *vomiting*, by pouring emetic solution into the veins, the contents of the bladder were discharged as from the natural stomach. The conclusion has been too hastily formed, that the stomach has therefore nothing to do with the action of vomiting. But it ought to be recollected, that the bladder represents a relaxed stomach, whereas the stomach is muscular and active, and capable of resisting the action of the abdominal muscles and diaphragm, unless there be a consent of the action of the stomach and the action of the muscles of respiration. Thus if we could suppose that a man had a distended bladder for a stomach, whilst he exerted himself forcibly and retained his breath the contents would be discharged. So would they if he lay with his belly over a yard-arm. But no such discharge takes place from the natural body, because the upper orifice of the stomach resists! This resistance does not take place in vomiting; and therefore, I say, the stomach has to do with vomiting, in spite of all the cruelties which have been committed.

The singultus is the partial exertion of the sympathy betwixt the upper orifice of the stomach and the diaphragm, by which a kind of weak spasmodic action is excited in it, but without a concomitant inverted action in the stomach and œsophagus. It is a convulsive and sonorous inspiration, owing to an irritation of the upper orifice of the stomach and œsophagus, but not exactly of that kind which causes inversion of the natural actions of the stomach. Thus we have the singultus from gluttonous distention of the stomach, from some medicines

and poisons, from some crude aliment, or even from some foreign body sticking low in the œsophagus, or from inflammation. The borborygmi and rumination seem to be gentler inverted actions of the upper orifice of the stomach and œsophagus, unassisted by any great degree of compression of the stomach by the abdominal muscles and diaphragm.

The full action of vomiting is preceded by inspiration, which seems a provision against the violent excitement of the glottis, and the danger of suffocation from the acrid matter of the stomach entering the wind-pipe; for by this means the expiration and convulsive cough accompanying or immediately following the action of vomiting, frees the larynx from the ejected matter of the stomach. But the action of the diaphragm is farther useful by acting upon the mediastinum, which embraces the œsophagus, and no doubt supports it in this violent action.

The subject is very interesting, but I must enlarge no more upon it here.

NERVOUS OR VASCULAR COAT OF THE STOMACH.

WHAT Haller calls the nervous coat, is the cellular structure in which the vessels and nerves of the stomach ramify and divide into that degree of minuteness which prepares them for passing into the innermost or villous coat. It may with equal propriety be called the nervous, the vascular, or the great cellular coat.* Taking it as the third distinct coat of the stomach, it is connected with the muscular coat by the SECOND CELLULAR COAT, and with the villous coat by the THIRD CELLULAR COAT. Strictly, however, it is the same cellular membrane, taking here a looser texture to allow of the free interchange and ramification of vessels. When macerated, it swells and becomes like fine cotton, but has firmer and aponeurotic-like filaments intersecting it; it can be blown up so as to demonstrate its cellular structure.† It is in this coat that anatomists have found small glandular bodies lodged, especially towards the extremities or orifices of the stomach.

VILLOUS COAT.—This is the inner coat, in which the vessels are finally distributed and organized to their particular end. It is of greater extent than the outer coats of the stomach; which necessarily throws it into folds or plicæ. These folds take, in different animals, a variety of forms: but they are

* To call it cellular coat, however, would be to confound it with the three cellular coats generally enumerated by authors.

† Winslow, sect. viii. p. 64.

simple in man; from the œsophagus they are continued in a stellated form upon the orifice, but form no valve here. In the body of the stomach they are more irregular, sometimes retiform, and sometimes they form circles or squares, but they have generally a tendency to the longitudinal direction. In the pyloric orifice the villous coat forms a ring, called the valve of the pylorus, which, however, has no resemblance to a valve in its form or action. This ring is not formed by the inner coat of the stomach alone, but by the inner stratum of fibres of the muscular coat, the vascular and cellular coats, and the inner or villous coat. The effect of all these coats, reflected inward at the lower orifice, is to form a tumid and pretty thick ring, which appears like a perforated circular membrane when the stomach has been inflated and dried; but in neither state is its direction oblique so as to act as a valve. It seems capable of resisting the egress of the food from the stomach, or the return of the matter from the duodenum, merely by the action of the circular fibres which are included in it.

In the inner surface of the stomach of those dying suddenly, and who were previously in health, *plicæ* may be observed more or less distinct, according to the state of contraction of the muscular coat of the stomach. But in those dying of disease and with relaxed stomach, no folds of the inner coat of the stomach are to be seen.

The glands of the human stomach are very small, but in great numbers around the termination of the œsophagus. In this description I am looking to the plate of Sir Everard Home. Brunner described the glands of the stomach as seated on the curvatures. Glands are distinctly to be seen in the stomach of birds and many quadrupeds, and in fishes and serpents, (Haller.) But it is to Sir Everard Home that we owe the most careful observations on this subject. His lectures on this subject, delivered in the College of Surgeons, had that grave character of investigation befitting the place, while they possessed an interest beyond example.*

Gastric fluid.—There is secreted into the stomach a fluid, which is the chief agent in digestion. The most common opinion is that it flows from the extreme arteries of the villous coat in general, partly from the glands. When pure, it is a pellucid, mucilaginous liquor, a little salt and brackish to the taste, like most other secretions, and having the power of retarding putrefaction and dissolving the food. It acts on those substances which are nutritious to the animal, and which are peculiarly adapted to its habits.

* These lectures are now published.

It seems to be a peculiarity in the human stomach, that it has a greater capacity of digesting a variety of animal and vegetable bodies. But I should at the same time conceive that the natural power of digesting the simple and appropriate food is diminished as the stomach gains the power of dissolving a variety of substances.* In other creatures, a sudden change of food is rejected, and the powers of the stomach are found incapable of acting duly on the aliment, though time so far accommodates the gastric fluid to the ingesta, that the animalization becomes perfect. Mr. Hunter speaks of the power of cattle eating and digesting their secundines.† I have seen the membranes coiled in the bowels of a cow; but I too hastily concluded this to be the cause of death. I am corrected by the authority of Dr. Jenner and Dr. Adams. The fact is sufficiently ascertained, that the nature of the digestive process may be so far altered that graminivorous animals may be made to eat flesh, and carnivorous animals brought to live upon vegetables. This throws us back from the simple idea which we should be apt to entertain of the nature of the change produced by digestion, viz. that it is simply chemical. For we see that the nature of the solvent thrown out from the stomach, and its chemical properties, may be changed by an alteration in the action of the coats of the stomach. Thus we are baffled in our inquiries, and brought back to the consideration of this living property, which can so accommodate itself to the nature of the aliment.

The gastric fluid has been collected from the stomachs of animals after death, by sponges which the animal has been made to swallow, or which have been thrust down into its stomach, incased in perforated tubes. And, lastly, it has been obtained by exciting the animal to vomiting, when the stomach was empty; for the secretions of the stomach are then poured out unmixed with food.‡ Although by these means a fluid may be obtained which may properly be called the *succus gastricus*, yet it must contain a mixture of the saliva, and secretions from the glands of the œsophagus and pharynx, with the glandular secretions of the stomach, and the general vascular secretion from the surface of the stomach. It is a fluid, then, upon which the chemist can operate with no hope of

* Dr. Adams's experiments go to prove that the gastric juice is always the same. An early friend of mine, Dr. Cheyne, whose works on the diseases of children have sufficiently proved his minuteness and accuracy of observation, lately told me, that on the principle here expressed he has been very successful in humouring the delicate stomachs of his patients; he has found that two kinds of food received at once into the stomach will be rejected; when separately, they will not disorder the stomach.

† See Observations on Digestion.

‡ By Spallanzani.

a successful or uniform result. And, indeed, chemistry seems no farther to assist us in forming an accurate conception of the changes induced upon the fluids in the alimentary canal, than that the more perfect, but still very deficient, experience of the modern chemist successfully combats the speculations of the chemists of former ages. For example, it was formerly supposed that digestion was a fermentation, and that this fermentation was communicated and propagated by the gastric juice. It is now found that the gastric juice has properties the reverse of this; that it prevents the food from taking an acid or putrefactive fermentation; that its acts by corroding and dissolving the bodies received into the stomach; and that it is itself at the same time converted into a new fluid, distinct in its properties.* It is almost superfluous to observe,† that the gastric juice has no power of acting upon the coats of the stomach during life; whether this be owing to the property in the living fibre, of resistance to the action of the fluid, or that there is a secretion bedewing the surface, which prevents the action, it is not easy to say; but more probably it is owing to the resistance to its action inherent in a living part.‡

Mr. Hunter supposed it necessary that the animal should be in health, immediately preceding death, in order that the secretion of the gastric juice may be natural and capable of dissolving the dead stomach: but I have found the stomach of children, who have died after a long illness, digested by the secretion of the stomach. See Examples in my Collections.

Of digestion.—By trituration and mastication, and the union of the saliva with food in the mouth, it is prepared for the more ready action of the stomach upon it. No farther

* The most curious fact is that property of the coats of the stomach, or of the fluids lodging in the coats of the stomach, by which milk and the serum of the blood are coagulated. It has been found that a piece of the stomach will coagulate six or seven thousand times its own weight of milk. This action seems a necessary preparation for digestion, which shows us that the most perfect and simply nutritious fluid is yet improper, without undergoing a change to be received into the system of vessels. For example; milk and the white of eggs are first coagulated, and then pass through the process of digestion. See J. Hunter, Animal Economy, Observations on Digestion.

† I do think it a very self-evident fact, notwithstanding Dr. Adams's taunting manner of quoting these words. See that very interesting work on *Morbid Poisons*, preface, xxxvi.

‡ Mr. Hunter is one great authority on this subject, &c.

See also Morgagni Advers. III. A. XXIV.

Dr. Adams on Morbid Poisons, preface, and Mr. A. Burns's, of Glasgow, paper. Edin. Journal, Ap. 1810. Amongst other curious facts stated by Mr. Burns is this, that he has found all the length of the alimentary canal dissolved into a pulpy glutinous mass. I may say that, connected with the discussion, there may enter a question as to what is the cause of a tenderness sometimes to be observed in all the membranes of the body. I have to-day examined the viscera of a negro, where the intestines were particularly tender, but the pericardium and valves of the heart more remarkably so still.

change is induced upon it than the division of its parts. But in the stomach, the first of those changes (probably the most material one) is performed, which by a succession of actions fits the nutritious matter for being received into the circulation of the fluids of the living body, and for becoming a component part of the animal. For now the gastric juice acting on this fluid mass quickly dissolves the digestible part, and entering into union with it produces a new fluid, which has been called chyme, a thick or viscid and turbid fluid. The mass has changed its sensible and chemical properties; it has suffered the full action of the stomach, and by the gradual and successive muscular action of the stomach it is sent into the duodenum. The food is converted into chyme by the operation of the gastric fluid, by an operation peculiarly animal, a process of life. And the conversion of the food into a new substance is unattended by any chemical change, strictly speaking, if by chemistry we understand the mutual influence of dead matters in forming compounds or separating and extricating the constituent parts. Animal or vegetable matter in the heat and moisture of the stomach would quickly fall into the fermentations; but the living property of the stomach prevents this. In this I speak of the stomach in health; when weak, then the symptom announcing the diminished power is the extrication of gas, or the formation of acids, with oppression and uneasy sensations. The contents of the stomach consist of air (partly swallowed, partly extricated by chemical change, but still more in all probability by the heat,) of chyme; and of a grosser part incapable of becoming nutritious, and the separation of which from the chyme is accomplished by the action of the canal. Now the stomach being stimulated by fulness, by flatus, and more still by the peculiar irritation of the food prepared by digestion, the muscular coat is brought into action, and the contents of the stomach delivered into the duodenum.

A case is on record which finely illustrates the function of the stomach. A woman, presented in the clinical ward of La Charité, to Corvisart, who had a fistulous opening in the left side of the epigastric region, which communicated with the stomach, and through which part of the villous coat of the stomach could be seen, of a vermilion colour, and covered with mucus, and having certain plicæ.

The vermicular undulations of these rugæ of the inner coat of the stomach could be observed. Three or four hours after this woman took food, she felt an irresistible desire to raise the dressings from the fistula. Then flatus was forcibly discharged with the food, which was reduced into a greyish pulp, having neither acid nor alkaline properties. After emptying the stomach, which she washed by sending through it a pint

of infusion of chamomile, she found perfect ease. In the morning a small quantity of fluid like saliva, ropy and clear, was found at the orifice. This was probably the gastric fluid ; it possessed neither acid nor alkaline qualities.

On her death the hole in the stomach was found eight fingers breadth from the left extremity, or one third of the whole length of the stomach distant from the pyloric orifice.

From this case we learn, 1. that the stomach is subject to a gentle vermicular motion; 2. that the food received into the stomach is retained three or four hours in the great left extremity of the stomach ; 3. that when it has undergone the process of digestion there, it is conveyed, with rather a sudden impulse, into the pyloric extremity of the stomach ; 4. that the chyme thus formed, has undergone an animal process, becoming neither acid nor alkaline. Contemplating this illustration of the function of the stomach as a digesting organ, with the according action of its muscular fibres above described, a solid ground-work is afforded for the pathology of this organ.

Hunger and thirst. We are solicited to take food by the uneasy sensation of hunger, and by the anticipation of the voluptuous sating of the appetite, and by the pleasures of the palate. Hunger is considered as the effect of the attrition of the sensible coats of the stomach upon each other by the peristaltic motion of the stomach and compression of the viscera. This appears to be too mechanical in explanation. If the sensation proceeded merely from such attrition of the coats of the stomach, food received into the stomach would be more likely to aggravate than to assuage the gnawing of hunger ; to excite the action of the stomach would be to excite the appetite, and an irritable stomach would be attended with a voracious desire of food. Something more than mere emptiness is required to produce hunger. By some, hunger is supposed to proceed from the action of the gastric fluid on the coats of the stomach, by others it is attributed to the dragging of the liver, now no longer supported by the full stomach. Hunger is like thirst, a *sense* placed as a guard, calling for what is necessary to the system, and depending on the general state of the body. Morbid craving may proceed from many causes ; a tape worm has occasioned bulimia, and spirits and high seasoning excite the appetite even when the stomach is full.

Thirst is seated in the tongue, fauces, œsophagus, and stomach. It depends on the state of the secretions which bedew these parts, and arises either from a deficiency of secretion, or from an unusually acrid state of it. It would appear to be placed as a monitor calling for the dilution of the fluids by drink, when they have been exhausted by the fatigue of the body and by perspiration, or when the contents of the stomach

require to be made more fluid—the more easily to suffer the necessary changes of digestion.

The change on the secretion of the tongue and fauces from disorder of the stomach, is not, I imagine, a consequence of an influence communicated along the continuous surface. It has its origin in this natural constitution of the parts; this connection which nature has established betwixt the stomach and tongue, betwixt the appetite and the necessity of the system. The state of the tongue, the loose or viscid secretions of the throat and fauces, even the secretion of the saliva, the irritability of the larynx, are influenced by the stomach. The more permanent and demonstrable effects on the tongue are principally attended to; which perhaps is the reason that we only know by this that the stomach is disordered, not how it is affected.

The cardiac orifice is the chief seat of all sensations of the stomach, both natural and unusual, as it is the most sensible part of the stomach. Indeed we might presume this much by turning to the description and plates of the nerves; for we shall find that this upper part of the stomach is provided in a peculiar manner with nerves, the branches of the par vagum.

The sympathy of the stomach with the rest of the intestinal canal, the connection of the head and stomach in their affections, the effect of the disorder of the stomach on the action of the vascular system and of the skin, and the strict consent and dependence betwixt the stomach and diaphragm and lungs, and in a particular manner with the womb, testicle, &c.—and again, the connection of the stomach with the animal economy, as a whole,—must not escape the attention of the student of medicine.

SECTION III.

OF THE INTESTINES.

That portion of the alimentary canal which extends from the lower orifice of the stomach to the anus is called the intestines. It is divided into the small intestines, and the great intestines; the small intestines are divided into the *duodenum*, *jejunum*, and *ileon*. The great intestines are divided into *cæcum*, *colon*, and *rectum*.

The marked difference of function is betwixt the small intestines and the great intestines. But betwixt the form and capacity of the stomach, the form and capacity of the small in-

testines, and the form and capacity of the great intestines, there is always a certain relation preserved in the different classes of animals.

The small intestines are estimated to be in length 26 feet, or from four to five times the length of the body, and the great intestines one length of the body, or about six feet. The younger the subject, the longer the intestinal canal. In an infant they were found to be upwards of eleven times the length of the body. In a child of one foot nine inches they were upwards of eight times the length of the body. In a child three feet one inch they were found to be seven times and one half the length of the body.*

Is this difference to be accounted for by supposing that a different food is applicable to the several ages, or is it an increase of absorbing surface accommodated to the necessities of the body while growing.

In the carnivorous animal the whole of the canal is shorter, being about five times the length of the animal, for example in the lion. In the herbivorous animals the intestines are longer and more complicated, affording means for the retention or the delay of the descent of the food.

Of the small intestines the first portion is the division extending from the orifice of the stomach till it is encumbered in the mesocolon. It is improperly called the duodenum.

THE DUODENUM

Stands distinguished from the general tract of the small intestines by its shape, connections and situation. It has been called duodenum, because it was usual to measure its extent by the breadth of twelve fingers. It is greatly larger than any other part of the small intestines; irregular and sacculated; more fleshy; and, although it has fewer plicæ, it is more glandular and more vascular; but its greatest peculiarity, and that which must convince us of its importance in the animal economy, and of the necessity of attending to it in disease, is this, that it is the part which receives the biliary and pancreatic ducts, and in which a kind of second stage of digestion takes place. The intestine takes a course across the spine from the orifice of the stomach. First it goes in a direction downward; then it passes upward till it touches the gall bladder; then making a sudden turn it descends directly near to the right kidney, and is then involved in the lamina of the mesocolon: it then takes a sweep towards the left side, obliquely across the

* Sir Everard Home's Lectures.

spine and a little downward; from this description it is obvious that it must be longer than the breadth of twelve fingers, and indeed I call duodenum all that portion of the intestines which is above the mesocolon, preferring a natural to an arbitrary boundary.* As in this extent, besides being tied down to the spine by the mesocolon, it has the peritoneum reflected off from it at other points, we have to remark the *ligamentum duodeno-renale*, *ligamentum duodeno-hepaticum* already described.

Although we shall presently treat of the coats of the small intestines in general, yet it may not be improper here to observe what are announced as peculiarities in the coats of this first division. The first or peritoneal coat is imperfect, as must already be understood: for it does not invest the whole circumference of the gut; it ties it down more closely, or it merely contains it in its duplicature, while a greater profusion of cellular membrane accompanies this than the other divisions of the intestines. The muscular coat is stronger than that of the jejunum and ileon; the plies formed by the inner coats, smaller than those of the other part of the small intestine, and having more of a glandular structure. At the lower part of the first incurvation of the duodenum, the inner coat forms a particular process like to those which are called valvulæ conniventes; and in this will be discovered the opening of the biliary duct, within which also the ductus pancreaticus generally opens.

It is not without some reason that anatomists have considered the duodenum as a second stomach, calling it ventriculus secundus, and succenturiatus; for there is here performed a change upon the food, converting the chyme (as they have chosen to call it,) which is formed in the stomach, into perfect CHYLE. But to suppose that the chyme is perfected in the duodenum, is to suppose the biliary and pancreatic secretions necessary to the formation of chyle; a point which is not allowed; for many suppose that the bile is merely a stimulus to the intestines, holding a control over their motions; others, that it is useful only in separating the chyle from the excrement; or again, that the bile is decomposed, part entering into the composition of the chyle, while the other goes into that of the fæces; it seems to bestow upon them a power of stimulating the intestinal canal in a greater degree; and as the chyle is formed occasionally without the presence of bile, we may be induced the more readily to allow that the bile does not, in

* Ruysch calls it "Intestinum digitale, vel intestinum rectum brevissimum." Adversar. Anat. Decad. II.

See a good description of the duodenum by M. Laurent Bonazzoli, in the Transactions of the Academy of Bologna. And the Dissert. L. Claussen, de duodeni situ et nexu. Sandifort Thes. V. III. Monro, Medical Essays.

the natural actions and relations of the system, enter into the composition of the chyle. At all events, we see that it is the bile which is the peculiar stimulus of the intestinal canal, and that when interrupted in its discharge from the ducts, the motions in the belly are slow, and costiveness is the consequence.

There are poured into the duodenum, from the liver and pancreas, secretions which have an extensive effect on the system of the viscera; and we must acknowledge that the derangement of these secretions must operate as a very frequent and powerful cause of uneasiness, and therefore that the duodenum must often be the seat of uneasy and distressing symptoms. We may observe that, from the course of the duodenum, pain in it should be felt under the seventh or eighth rib, passing deep, seeming to be in the seat of the gall bladder, and stretching towards the right hypochondrium, and to the kidney, and again appearing as if on the loins. We may observe farther, that from the connections of this portion of the intestine, and from the manner in which it is braced down by the mesocolon, spasm, when flatus is contained in it, will sometimes produce racking pains. Nay farther, when the irregularities of digestion affect the duodenum, and spasm and digestion follow; the distention causes it to press upon the gall-bladder, and the pressure and excitement together cause an irregular and often an immoderate flow of bile, which with the acrid state of the food produces anxieties and increased pain, inverted motion, and vomiting.

We must not forget, that the inverted action of the stomach draws quickly after it the inverted motion of the duodenum. It may be of consequence to attend to this in the operation of an emetic, for the stomach will sometimes appear to be discharging foul and bilious matter which we naturally may suppose to have been lodged in it, but which has actually flowed from the duodenum, or has even come recently from the ducts in consequence of the operation of the vomit.*

From a defect in the natural degree of the stimulating power of the bile, it will accumulate in the duodenum, occasioning anxiety and loss of appetite, and even congestion of blood and a jaundiced skin; we may certainly affirm that these at least are often connected. Such accumulation in the duodenum must be attended with a languid action of the whole canal, and inactivity of the abdominal viscera, because the peristaltic motion is begun here in the natural action of the intestines; and

* Indeed vomiting in consequence of concussion and compression upon the whole contents of the abdomen, and in a particular manner on the liver, affords most powerful means of operating upon the infarction and remora of the blood in the hepatic system.

if the proper stimulus be deficient here, so must it be in the whole system of the viscera. Hence the necessity of rousing the activity of the liver by evacuating the whole canal.

I may further observe, that it has been the opinion of the most respectable old physicians, those whose knowledge of diseases has been drawn from an acquaintance with anatomy, from the frequent inspection of dead bodies, and the observation of the symptoms during life, that the study of the diseases connected with the duodenum is the most important which can occupy the attention of the medical inquirer.*

OF THE JEJUNUM AND ILEON.

The small intestines, under the name of jejunum and ileon, occupy the space in the middle and lower part of the abdomen, the great mass forming convolutions in the umbilical region. The canal of the small intestines is gradually and imperceptibly diminished in diameter as it is removed from the lower orifice of the stomach; so that the termination of the ileon in the caput coli is considerably smaller than the duodenum. This tract of the small intestines performs the most important function of the chylopoietic viscera (if any can be said to be peculiarly important where the whole is so strictly connected;) for here the food is moved slowly onward through a length of intestine four times the length of the body, and exposed to a surface amazingly extended by the pendulous and loose duplicatures of the inner coat. Here the fæces are gradually separated from the chyle, and the chyle adhering to the villi is absorbed and carried into the system of vessels.

The JEJUNUM† is the upper portion of the small intestine. Its extent is two-fifths of the whole. Its convolutions are formed in the umbilical region.

The ILEON lies in the epigastric and iliac regions, surrounds the jejunum on the sides and lower part, and forms three-fifths of the whole extent of the intestine from the mesocolon to the valve of the colon. The coats of the ileon are thinner and paler; the valvular projections of the inner coat less conspicuous; and the mucous glands become more apparent in the lower portion.

There is sometimes found a lusus in the lower part of the ileon before it passes into the colon; a blind pouch or cæcum is, as it were, attached to the ileon, resembling the caput coli. I have found many instances of this, and several specimens

* See Sandifort, vol. iii. p. 288. See Hoffman.

† So named from its being more generally empty.

may be seen in my collection. Sometimes there is more than one cæcum in the course of the ileon.*

THE PERITONEAL COAT AND MESENTERY.

The peritoneal coat of the small intestines is of the same nature with that of the stomach. It is thin, smooth, and possessing a certain degree of elasticity. On the surface it has a moisture exuding from its pores ; and it firmly adheres to the muscular fibres beneath by a very dense cellular substance. Its transparency makes the muscular fibres, blood-vessels, and lymphatics easily distinguishable ; and when it is dissected or torn up, the longitudinal muscular fibres will be found in general attached to it. Its use is to give a smooth surface and to strengthen the intestine, and in a great measure to limit the degree of their distention.

The peritoneal coat of the intestine is continued and reflected off upon the vessels and nerves which take their course to the intestine ; or, what is the same thing, and indeed is the more common description, the two lamina of the peritoneum which form the mesentery, after proceeding from the spine and including the vessels, nerves, and glands belonging to the tract of the intestine, invest the cylinder of the intestine under the name of peritoneal coat.†

The mesentery is composed of membranes, glands, fat, and the several systems of vessels, arteries, veins, lacteals, and nerves. As in reality it is a production of the peritoneum, it may be said to arise from the mesocolon, or the mesocolon from the mesentery, reciprocally. But at present we may trace the mesentery from the root of the mesocolon—for the jejunum, emerging from under the embrace of the mesocolon, carries forward the peritoneum with it ; and the lamina of the peritoneum, meeting behind the gut, include the vessels which pass to it and from the mesentery. This connection of the small intestines by means of the prolongation of the peritoneum, while it allows a considerable latitude of motion, preserves the convolutions in their relations, and prevents them from being twisted or involved. But it is by the walls of the abdomen that the intestines, as well as the more solid viscera, are supported ; for when the bowels escape by a wound, a por-

* The appendices cæcales of the ileon have given birth to a curious question in the pathology of hernia. See " Hernia ab ilii diverticulo." Morgagni, Adv. Anat. III. " Hernie formée, par l'appendice de l'ileon." Lettre, Mem. de l'Acad. Royale des Sciences, an. 1700 ; Ruysch, Palfin. &c. See cases of anus at the groin in the Museum.

† See Plate I. 5, 6, 7, 8.

tion of an intestine will hang down upon the thigh, unrestrained by the connection with the mesentery.

The mesentery begins at the last turn of the duodenum, or beginning of the jejunum. Its root runs obliquely from left to right across the spine. Here it has consequently no great extent; but as it stretches toward the intestines, it spreads like a fan, so that its utmost margin is of very great extent, being attached to a portion of the canal, which we have estimated at four times the length of the body. In the middle of the small intestine, the mesentery has its greatest extent or breadth; towards the beginning of the duodenum and the termination of the ileon, it is shorter, and more closely binds down the intestine.

MUSCULAR COAT OF THE INTESTINES.

The peritoneum is united to the muscular coat by a very delicate and dense cellular membrane; which in the enumeration of the coats we must call the first cellular coat, but which really does not deserve the name of a distinct coat; for, as already said, the outer lamina of the muscular coat is raised with the peritoneum, and adheres intimately to it. The fibres of the muscular coat of the intestines are simpler than those of the stomach; for here there are only two sets of fibres, the longitudinal and circular fibres. The outer stratum consists of the very minute and delicate longitudinal fibres. Indeed, when the system has been exhausted by a long and debilitating illness, with scarcely any excitement of the intestinal canal, these fibres are not to be observed. In a man who has been cut suddenly off by disease, or who has died a violent death, they become more demonstrable; and in diseases where there has been congestion and excited action in the intestines, they are of course still stronger and more discernible. The internal stratum of the muscular fibres is much stronger and more easily demonstrated. These fibres will be observed much stronger about the duodenum and upper part of the jejunum, but they become weaker and more pellucid towards the extremity of the ileon. Tracing any particular fibre of the circular stratum, it is found to form only a segment of a circle, a part of the circuit of the intestine. It seems lost amongst neighbouring fibres or cellular connections; but still, taken together, the circular muscular fibres uniformly surround the whole gut.*

To account for that action of the intestines which urges on

* Morgagni Adversaria Anatomica III. Animadversio V.

the food, we may suppose a greater degree of irritability and activity to reside in the upper portion, where of course is commenced that action which is successively propagated downwards, carrying the fæces into the lower part of the canal. Some anatomists have ingeniously imagined that the inner stratum of fibres surrounds the intestine, not in a circular direction, as was asserted by Willis, but obliquely and in a spiral course; from which followed a simple explanation of their effect, since the contraction of the fibre winding lower in the intestine, pursued the contents with a uniform, progressive constriction.

Physiologists have made a distinction in the motion which they have observed in the intestines of living animals. The one they call the vermicular, and the other the peristaltic motion. Upon looking into the belly of a living animal, or of one newly killed, there may be observed a motion among the intestines, a drawing-in of one part and a distention and elongation of another part of the convolution. This motion has some resemblance to the creeping undulating motion of a reptile, and has got the name of vermicular motion. On the other hand, the direct contraction of the gut by the constriction of the circular fibres is the peristaltic motion. We must not however allow ourselves, from the loose expressions of authors, to imagine that these circular straight fibres act separately; on the contrary, excited by the same stimulus, they have a simultaneous motion to the effect of accomplishing the perfect contraction of the gut and motion of its contents.*

While the stimulus is natural, the contraction of the muscular coat is in a regular series from above downward, and, the lower part contracting before the upper is completely relaxed, the food must be urged downwards into the lower portion. Nay, I should imagine that the lower portion becomes relaxed at the same time that the upper portion is contracted.†

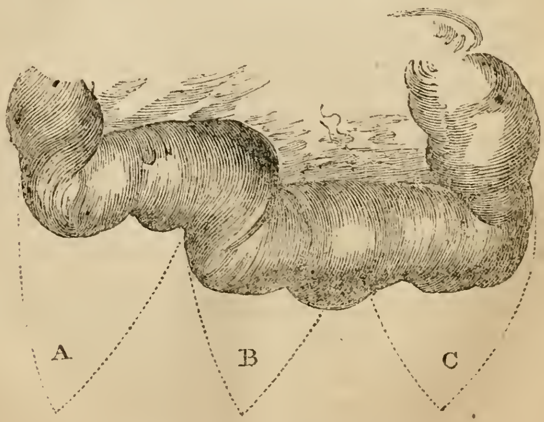
ANTI-PERISTALTIC MOTION.

When the successive contraction of the muscular fibres of the intestines is opposed in its natural course downward, either

* Neither can I allow that the acting of the longitudinal fibres in one portion of an intestine dilates that which is below, otherwise than through the compression of food and flatus.

† From the experiment of Haller and of others, it is proved that the irritability of the intestines long survives that of the heart; that the intestines are in general in lively motion, when no motion can be observed in the stomach; but that sometimes the motion of the stomach continues longer than that of the intestines. It is proved also that the action of the intestine is adequate to the motion downward and the discharge of fæces, without the aid of the abdominal muscles. See *Mem. par Haller sur les Mouvemens des Intestines*; and *Opera Minora*, p. 393.

by a violent stimulus (the effect of which is to cause a more permanent contraction in the coats, and one which does not readily yield to the relaxation that follows, as in the natural contraction,) or when there is a mechanical and obstinate interruption to the contents of the bowels; then is the natural action reversed. This anti-peristaltic motion arises thus; a portion of the intestine being constricted, and not yielding to the contraction which, in the natural action of the gut, should follow in order, the motion of the gut must be stationary for a time, until the part above that which is contracted becomes relaxed; then the contents of the intestine finding a free passage upwards, and that portion contracting and propelling the matter still upwards and retrograde, (since it is opposed by the contraction below,) a series of retrograde or anti-peristaltic motions are begun and propagated. The course of the action being changed, the contraction of the gut is not followed by the dilatation of the portion below, but by that above. By this means the matter of the lower portion of the intestinal canal is carried into the upper part, and there acting as an unusual stimulus, it aggravates and perpetuates the unnatural action. Nay, from experiments it appears that a permanent irritation will cause an accelerated motion in both directions; that from the point stimulated there will proceed downward the regular series of contractions and dilatations, while the motion is sent upwards and retrograde from the same point of the intestine toward the stomach.* And this observation, the exhibition of medicine and the diseases of the intestines confirm. But farther we may observe, that the food is not uniformly moved downward; it is shifted and agitated by an occasional retrograde motion thus:



* Haller, loc. cit. Exper. 424.

The portion of the intestine included under A contracts and sends its contents into B. B contracting sends its fluid contents in part backward into A, but in a greater proportion into C. While the contents of the middle portion are sent into the lower part in a greater proportion than into the higher division, the tendency of the food will be in its natural course, downward; whilst at the same time it suffers an alternate motion backward and forward; so that it is more extensively applied to the absorbing surface of the intestines.

The stimulus to the intestines is matter applied to their inner coat: and although there is much sympathy in the whole canal, yet unless there be matter within a portion of the canal, that particular part has little action. Accordingly, when there is obstruction to the course of the aliment, by whatever cause it may be produced, the portion below becomes shrunk and pale, and free from the effects of inflammation; while that stimulated by the food, being in a high state of excitement, irritated by the presence of matter which it is unable to send forward, evacuated only partially by an unnatural and highly excited retrograde action, it becomes large, thick in its coats, strong in its muscular fibres, and greatly inflamed, till it terminates at last in gangrene.*

The unusual excitement of the muscular fibres produces a very curious effect in the intus-susceptio, or the slipping of one portion of the gut within another. This may be done by applying acrid matter to the intestines of living animals; and I have no doubt that it has been produced by giving purges too strong and stimulating in cases of obstruction of the bowels. By the contractions of the muscular coat greatly excited, the intestine is not only diminished in diameter so as to resemble an earth-worm,† but in length also. This great contraction of the outer coats accumulates the vascular and villous coat as if into a heap; which from the compression of the muscular coat is forced into the neighbouring relaxed portion. This first step leads only to a succession of actions; for the fibres of the relaxed or uncontracted part, sensible to the presence of this accumulated and turgid villous coat, contracts in succession so

* Haguenot gives an experiment illustrating the cause of ileus. He tied a ligature about the intestine of a cat, and found no antiperistaltic motion excited. This is not wonderful; it is the excitement arising from matter within the gut, to which there is no exit, and not the stricture of it, which is the cause of the violent symptoms. Many cases in the Museum will give the young student a correct judgment on this subject.

Vide Scholium sub tit. Calculus insignis Ilii. Observ. F. Biumi. Sandif. Thes. vol. iii.

† See Haller's Experiments, *Opera Minora*; and "Dissections of the Atrophia Ablactatorum;" with plates; by Dr. Cheyne. Sandifort, vol. ii. p. 381. in Dysenteriæ.—Ibid. 244.

as to draw a part of the contracted gut within the relaxed portion. If the irritation is done away or ceases quickly, as in the experiments on animals, another turn of the intestine coming into play distends this, and undoes the intus-susceptio. But if the cause continues, the intus-susceptio is continued; the included part of the gut is farther forced into the other. By these means the vessels going to the included part are interrupted; the villous coat swells more and more; and several feet of the upper portion of the intestine is often in this way swallowed down. Is it not however in the natural course downward that this preternatural action always proceeds; for, as the excitement is violent and unlike the usual stimulus of food, and as we know that an unusual excitement is very apt to cause an inverted action, it often happens that the intus-susceptio is formed by the lower portion of the gut being included in the part above.

VASCULAR COAT.

This third coat of the intestines, is a stratum of cellular membrane in which the vessels of the gut are distributed. It might with equal propriety be called the cellular coat; and is indeed what some anatomists have called the third cellular coat. By inverting the gut and blowing strongly into it, the peritoneal coat cracks and allows the air to escape into this coat; which then swells out, demonstrating its structure to be completely cellular.* Its use evidently is to suffer the arteries, veins, and lymphatics to be distributed to such a degree of minuteness as to prepare them for reflection into the last and innermost coat, and for entering into the structure of the villi: for they come to the extremity of the mesentery as considerable branches, but forming in this coat many branches, and these subdividing, their extreme branches are finally distributed to the inner coat. This is the coat in which, in some parts of the intestines, little glands or cryptæ are lodged.

VILLOUS COAT.

The most curious part of the structure of the intestines is the villous or inner coat; for by its influence is the chyle separated from the general mass of matter in the bowels, and carried into the system of vessels. To this, all we have been describing is merely subservient.

The villous coat has a soft fleecy surface; and being of

* An experiment to which Albinus attaches much importance. See also, in the Acad. de Bologna, a paper by Mr. D. G. Galeati on the fleshy coat of the stomach and intestines.

greater extent than the other and more outward coats, it is thrown into circular plaits which hang into the intestine, taking a valvular form. They have the name of VALVULÆ CONNIVENTES. Some of them go quite round the inside of the intestine; others only in part. They are of larger or smaller extent in different parts of the canal: for example; they begin a very little way from the lower orifice of the stomach irregularly, and tending to the longitudinal direction; further down they become broader, more numerous, and nearly parallel; they are of greater length, and more frequent in the lower part of the duodenum and upper part of the jejunum. These valvular projections have their edges quite loose and floating in the canal, and from this it is evident that they can have no valvular action. Their use is to increase the surface exposed to the aliment; to enlarge the absorbing surface; and at the same time to give to it such an irregularity that the chyle may lodge in it and be detained. Into the structure of these plicæ of the villous coat, the vascular or cellular coat enters, and generally in the duplicature a small arterial and venous trunk will be observed to run. That these plicæ are formed chiefly by the laxity of the connection and the greater relative extent of the inner coat, is apparent upon inverting the gut, and insinuating a blowpipe under the villous coat, for then you may distend the cellular substance of the vascular coat so as entirely to do away the valvulæ conniventes.

The pile or lanuginous surface from which this coat has its name, is to be seen only by a very narrow inspection, or with the magnifying glass. It is owing to innumerable small filaments which project from the surface like hairs at first view, but of a flat or rounded figure as they are exhibited in a state of fulness and excitement or depletion. They consist (as appears by the microscope) of an artery and vein, and lacteal or absorbing vessels, and to these we may surely add the extremity of the nerve. They have a cellular structure; they are exquisitely sensible; and when stimulated by the presence of fluids in the intestines, are erected and absorb the chyle. They are the extremities of the lacteal absorbing system, and their structure would seem to be subservient to the absorption by the mouth of the lacteal vessel.*

But the surface of this coat is not only an absorbing one, it also pours out a secretion; and, indeed, it is as a secreting surface upon which medicines can act, that it is to us one of the most powerful means of correcting the disordered state of the sys-

* See further of their structure under the title of the LACTEAL and LYMPHATIC SYSTEM, where the subject of absorption and the structure of the villi is treated.

tem. The fluid which is supplied by the surface of the intestines is called the liquor intericus; a watery and semi-pellucid fluid, resembling the gastric fluid. This fluid physiologists have affected to distinguish from the mucous secretion of the glands of the inner surface of the intestines; but it is impossible to procure them separate.*

GLANDS.

Anatomists have observed small mucous glands seated in the cellular membrane of the intestines,† the ducts of which they describe as opening on the villous surface of the intestines. They are seen as little opaque spots when the intestine is cut in its length and held betwixt the eye and the light. They have been chiefly observed in the duodenum; few of them in the general tract of the small intestines. Little collections or agmina are observed, which increase in frequency toward the extremity of the ileon. It is natural to suppose that as the contents of the intestines become in their descent more acrid and stimulating, there will be a more copious secretion of mucus in the lower intestines for the defence of the villous coat.

FUNCTION OF THE SMALL INTESTINES.

In concluding the view of the small intestine, we cannot fail, I think, to express a correct idea of their function; the matter ejected from the stomach is a greyish, pultaceous turbid mass. In the small intestine we find that a precipitation or separation of feculent matter has taken place from the nutritious part.

This nutritious matter called chyle is of a purer milky fluid, coagulable; so that already that most remarkable character of the circulating blood is assumed by the digested matter. And what is still more curious, already do we see that consent established betwixt the containing and the contained fluids which is the source of all the actions of a living body.

The chylous or nutritious matter from which the feculency is separated, is attracted by the surface of the villous coat of the intestine, and in an animal killed some time after taking food,

* It has been supposed that the fluids excreted from the surface of the intestines were furnished by very minute foramina (which are visible by particular preparation) in the interstices of the villi. See the letter of Malpighi to the Royal Society of London on the pores of the stomach; and the paper by M. Galeati in the Bologna transactions, on the Inner Coat, which he calls the Cribriform Coat. These pores according to Galeati, are visible through the whole tract of the canal, and particularly in the great intestines.

† Peyrus. Biblio. Manget. Brunnerus de glandulis duodeni. Morgagni Adversar. An. iii. viii. These he supposed additional pancreatic glands.

the matter may be seen coagulated upon the inner surface of the intestine.

Some are of opinion that the *chylification* is produced by the action of the bile, and that the effect of it is to precipitate the effete matter; but I am more inclined to believe that it is the office of the part of the intestines we are now considering, to separate by attraction the chyle from the mass of ingesta: for supposing that we were to give the office to the bile, that would be a mere precipitation, and could not explain the attraction of the chyle to the villi.*

It is more natural to suppose, that this very peculiar property of life, the coagulation, is bestowed through the influence of the villous surface of the intestine, than produced by the mere pouring in of a secretion like the bile.

SECTION IV.

OF THE GREAT INTESTINES.

The great intestines form that part of the intestinal canal which is betwixt the extremity of the ileon and the anus. They differ essentially from the small intestines in their size, form, and general character; and in the texture, or at least in the thickness of their coats.

The great intestine, beginning on the right side of the belly, rises before the kidney; passes across the upper part of the belly under the liver, and before or under the stomach.† Then making a sudden angle from under the stomach and spleen,‡ it descends into the left iliac region. Here making a remarkable turn and convolution, it descends into the pelvis by a curve running in the hollow of the sacrum.

The great intestines are accounted to bear a relation to the small intestines as five to twenty-five.

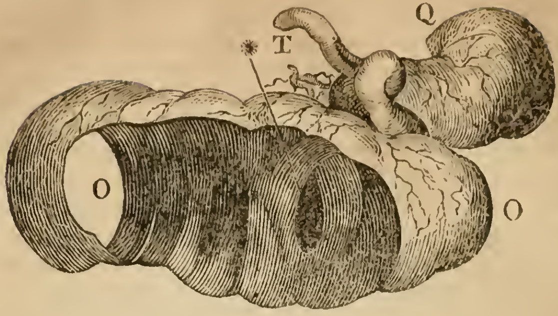
The natural division of this portion of the intestine is into the *cœcum*, *colon*, and *rectum*.§

* In Mr. Cooper's lectures in the College of Surgeons, this attachment of the chyle to the villi was considered as a discovery. But the statement will be found in former editions of this work.

† This turn of the colon from the right across the belly is flexura prima, superior dextra hepatica. Soemmerring.

‡ Flexura secunda, superior sinistra lienalis.

§ Some authors divide the great intestine into six parts, enumerating the Cœcum; pars vermiformis: the right: the left; and the transverse colon: and the last part or rectum.



VALVULA COLI.*

The extremity of the intestinum ileon enters, as it were, into the side of the great intestine at an angle.† And here there is a valvular apparatus formed by the inner membrane of the gut, which, more than any other circumstance, marks the distinction betwixt the small and great intestines; for as the effect of this valve is to prevent the regurgitation of the fæces into the small intestines, it marks sufficiently the nature of the change produced on the ingesta in their passage through the small intestine, and how unfit, in their changed and acrid state, they are to be longer allowed lodgment in the small intestines.

Upon opening the caput coli, or lower part of the colon, on the right side, and examining the opening of the ileon into it, we see a slit formed betwixt two soft tumid plicæ of the inner membrane of the gut: the one of these is superior; the other inferior. They are soft, and moveable, and seem scarcely calculated for a valvular action. But there is little doubt that when the great gut is distended or in action, they are calculated to resist the retrograde passage of the fæces into the ileon, though not absolutely to prevent it, as we know from what is vomited in the iliac passion.‡ In the form of the opening of the ileon, and in the broadness of the valvular membranes, there is considerable variety. The superior valve is transverse, smaller and narrower than the lower one; the lower one is longer, and takes a more extensive curve: and sometimes the lower one is so remarkably larger than the upper valve, that it gives a degree of obliquity to the insertion of the ileon into the colon, so as to approach to that structure which we see in the entrance

* *Valvula Coli* or *Valvula Bauhini* or *Valvula Tulpii.*

† Of the opening of the small intestine into the greater, see Morgagni Adversar. iii Animad. xi.

‡ *Morg. Advers.* A. iii. An. ix. *Kerckringius Observ.* xxxi.

of the biliary duct into the intestine, or the ureter into the bladder. At their extremities these valves coalesce and run into the common transverse folds of the colon: and this is what Morgagni has called the fræna or retinacula.* At this place of union of the ileon and colon the longitudinal muscular fibres of the ileon are mingled and confounded with the circular fibres of the colon.† The circular muscular fibres certainly enter so far into the composition of the valve, that they embrace the margin, and by contracting during life, must make the experiments on the action of this valve in the dead body less decisive than they would be, were we certain that this valve acts on principles strictly mechanical.

The discovery of the valve of the colon, and which, from its action in guarding the ileon, might rather be called the valve of the ileon, has been claimed or attributed to many anatomists, chiefly to Varolius, Bauhin, and Tulpius; and it sometimes receives the name of the two latter anatomists.

CŒCUM.

We have seen that the ileon is inserted into the side of the colon: now that portion of the gut which is below this union of the ileon is a round or slightly conical sac, from two to three inches in length. It is attached by cellular membrane to the iliacus internus muscle. It is not a regular sac, but is divided into large cells like those in the rest of the colon, and has some variety of form in different subjects.

PROCESSUS, SUE APPENDIX VERMIFORMIS.

There is appended to the cœcum a small gut, also blind; but bearing no relation in size or in figure to any part of the intestinal canal. This gut, from its smallness and twisted appearance, like the writhing of an earth-worm, has received the name of vermiformis. It is somewhat wider at the connection with the great intestine, and stands off obliquely, so that sometimes its inner membrane takes the form of a valve.‡ It scarcely ever is found containing fæces, but only a mucus excreted from its glands. In the fœtus the appendix vermiformis is comparatively much larger, its base wider; upon the whole, more conical, and containing meconium; and in the young child it often contains fæces. The cœcum and appendix in the human subject are just sufficient, like the form of

* Animad. xiii. † Winlow.

‡ Morgagni. M. Laur. Bonazzoli in the Acad. of Bologna.

the teeth, the stomach, and the intestines, generally to show that man holds an intermediate condition among the graminivorous and carnivorous animals. The cœcum is one of the many means of retarding the descent of the food through the colon; and it is found long and intricate in such animals as have a colon otherwise calculated to retain their contents. In carnivorous quadrupeds and birds the cœca are short; in the graminivorous quadrupeds and birds the cœca are long.

GREAT DIVISIONS OF THE COLON.

The great divisions of the colon are these: First, the RIGHT DIVISION of the COLON rises from the insertion of the ileon, and from that part of the great intestine which is tied down by the peritoneum and cellular membrane, and ascends on the right side of the small intestines, until it gets under the margin of the liver, and in contact with the gall-bladder. This part will be found to have some considerable variety in its form, as it is more or less distended.

THE TRANSVERSE COLON.*

The transverse colon is that part of the great intestine which takes a course across the belly, and which generally forms an arch before or immediately under the stomach. When this part of the colon however is much distended, being at the same time held down by the mesocolon, its angular turns reach under the umbilicus, nay even to the pelvis.†

The LEFT OR DESCENDING COLON is short: for from the place where the colon begins to bend down on the left side, to those violent turns which it takes before terminating in the rectum, it is but of small extent. Here it is attached to the diaphragm and psoas muscle.

The SIGMOID FLEXURE of the colon‡ is formed by a narrowing and contraction, and closer adhesion of the gut to the loins below the left kidney, and to the cup of the ilium, by the peritoneum, which has the effect of throwing it into some sudden convolutions. The colon then terminates in the rectum.

PECULIARITIES IN THE COLON DISTINGUISHING IT FROM THE SMALL INTESTINES.

The coats of the great intestines are the same in number

* COLON TRANSVERSUM. ZONA COLI.

† For the varieties in the situation of this intestine and the viscera in general, see Morgagni Adversar. Annat. ii. Animadver. ii.

‡ From its resembling the Roman S.

and in structure with those of the small intestines; but they are thinner and more difficult to be separated by dissection. The villi of the inner coat are smaller; indeed betwixt the villous coat of the ileon and the cœcum there is a distinction abruptly marked;* the mucous glands or follicules are sometimes very distinct; and, lastly, the muscular fibres have some peculiarities in their arrangement. The most characteristic distinction in the general appearance of the great and small intestines, is the notched and cellular appearance of the former. The cells of the colon being formed betwixt the ligamentous-like stripes which run in the length of the gut, have a regular threefold order. These cells give lodgment to the fæces; retain the matter; and prevent its rapid descent or motion to the rectum. Here the fluids are still more exhausted, and the fæces take often the form of these cells. When the great intestines are torpid, and inert in their motions, the fæces remain too long in the cells of the colon, and become hard balls or scybalæ. But when in this state of costiveness the intestines are excited by medicine, not only is the peristaltic motion of the intestines increased, but the vessels pour out their secretions, loosening and dissolving the scybalæ.†

MUSCULAR COAT.

The ligamentous-like bands of the colon form three fasciculi running in the length of the gut: one of these, obscured by the adhesion of the omentum, is not seen without dissection; and the other is concealed by the mesocolon.‡ These bands are formed by the longitudinal fibres of the gut, being concentrated into fasciculi, and not uniformly spread over the general surface, as in the small intestines: and being at the same time more firmly connected with the peritoneal coat, they give the appearance outwardly of ligament more than of muscular fibres.§ The inner or circular muscular fibres of the great intestines are like those of the small intestines, uniformly spread over their surface, and are stronger than those of the latter.

* Vide *Albin. Annot. Acad.* l. vi. c. viii. de intestinis et tab. ii. f. vii.

† See note of the pores of the intestines.

‡ Stratum liberum, stratum omentale & tertium mesocolicum.

§ See Morgagni. See also Galeati on the fleshy coat of the stomach and intestines, in the Memoirs of the Acad. of Bologna.

RECTUM.

The rectum* forms the last division of the great intestines; and I know no better proof of the impracticability of altering the names in anatomy than this, that anatomists have, in almost every age, insisted on the impropriety of calling this gut, which answers in its shape to the curve of the sacrum, a straight gut; and yet always, and to the present day, it is rectum.

From the last turns of the colon, called sigmoid, the gut is continued over the promontory of the last vertebra and sacrum (a little to the left side,) and falls into the pelvis. It runs down, in a curved direction, betwixt the sacrum and bladder of urine. In the upper part it is covered by the peritoneum, and has its fatty appendages like the colon, but less regular; and sometimes the fat merely deposited under the peritoneal coat. It is tied down by the peritoneum, in form of meso-rectum; but, deeper in the pelvis, it loses the peritoneum (which, as we have said, is reflected up upon the back of the bladder, and forms here lateral folds,) and the rectum is connected with the lower part of the bladder and vesiculæ seminalis by cellular membrane. In women, the muscular fibres of the rectum and vagina are intimately connected.†

The muscular coat of the rectum is particularly strong. The fleshy bands of the colon, spreading out, are continued down upon the rectum in an uniform sheath of external longitudinal fibres. The circular fibres of this part of the gut are also particularly strong; and towards the extremity, appearing in still stronger fasciculi, they obtain the name of sphincter, of which three are enumerated: and this, to distinguish it from the others, is called the intestinal or orbicular sphincter.

The internal coat of the rectum does not deserve the name of villous, nor of papillaris. Its surface is smooth, and there are often distinctly seen little foramina like the mouths of ducts or follicules, in part the source of the mucous discharge, which is sometimes poured out from this gut. Towards the anus the folds become longitudinal, and terminate in the notched-like irregularities of the margin.‡

* The name *rectum* is taken from the old anatomists who described from brutes. A Professor of Edinburgh calls it *curvum*, but this I cannot admit after reading *Morgagni Epist. Anat.* xiv.

† Winslow.

‡ The presence of stricture within the anus seems to have given rise to conversation about a valve here. Morgagni Adversar. An. iii. Animad. vi.

FUNCTION OF THE GREAT INTESTINES.

One obvious use of the great intestines is to be a receptacle for the useless part of the food, that the matter descending through the small intestine may not as frequently be voided. In the next place we see, that in proportion as the quantity of the ingesta is great to the really nutritious part, the great intestines are capacious and long. Thus in the goat, the great intestines are twenty feet nine inches in length, while in the lion they are three feet eight inches;* which is an increase of length of intestine in the herbivorous animal more than in the carnivorous, by as much as the quantity of the useless part of the vegetable food is great in proportion to the animal food.

Mr. Cooper, in his lectures to the College of Surgeons, gave the most diverting reason for the colon of sheep, and some other animals, being of a form calculated to retain the fæces, and form them into round dry pellets. It was to keep the wool and fur of their hips dry! Now these animals inhabiting lofty, dry, and sandy places, or extensive plains, they have this structure of the great intestines to enable them to extract the whole moisture from the food, and consequently the less frequently to require drink.

Professor Coleman has observed, that the water drank by a horse is very quickly conveyed through the canal, and deposited in the great intestines.

It is matter of daily proof, that the aliment is deposited in the right colon liquid; that in arriving in the rectum it is deprived of fluid; and that the lymphatics of the great intestine are found distended with a limpid fluid.

From such views I have long entertained the opinion, that a very principal office of the great intestines was to imbibe the fluid from their contents in proportion to the wants of the system.

But there is another office obviously performed by the intestinal canal: secretion, or rather excretion. The surface of the intestine is the organ by which that matter (the waste incident to the changes of the economy,) which is not carried away in the urine, is thrown out of the system.

The fæces contained in the great intestines, though offensive, are not putrid; and the rapid change which takes place in the alimentary matter by chemical combination, when voided, implies that there is a controlling influence of the great intestine over its contents. Hence we may believe with some pathologists, that, in derangement of function of the bowels, this

* Sir Everard Home's Lectures.

controlling influence being lost, such chemical change or putrefaction may take place in the contents of the colon, as to render them a new source of morbid irritation.

Not being satisfied with the observations I have met with on the different gases found in the intestinal canal, I may be excused omitting to notice them in a book of anatomy.

CHAP. III.

OF THE SOLID OR GLANDULAR VISCERA OF THE ABDOMEN.

The solid or glandular viscera of the abdomen are the liver, the spleen, the pancreas, the kidneys, the glandulæ capsulares.

SECTION I.

OF THE LIVER.

Our attention is now naturally drawn to the liver, as it holds in so eminent a degree the sovereignty over the motions of the intestinal canal, and as it is so strictly connected with it by its system of vessels, and by its functions. The liver is the largest viscus in the body, and as in its size and proportion to the whole body it is great, so are its connections in other respects with the whole system very intimate. This is particularly evident in the diseases of the liver, and was the cause of the ancients ascribing to it so eminent a place in the economy.

In all ages authors have paid particular attention to the liver, and have exercised their ingenuity in giving various explanations of its function. The ancients made it the supreme director of the animal system. They supposed that they could trace the nutritious fluids of the intestines through the meseraic veins into the porta and into the liver, and that it was there concocted into blood. From the liver to the right side of the heart they found the cava hepatica, carrying this blood formed in the liver to the centre of the system: and through

the veins they supposed the blood to be carried to the remote part of the body.

The liver is the largest glandular body of the whole system. It must perform a very important function in the animal economy. But I confess there is a considerable obscurity in the subject. Let us in the mean time attend to the anatomy.

Seat of the liver.—The liver is seated in the upper part of the abdomen, under the margin of the ribs, and towards the right side, or in the right hypochondrium. In the fœtus it occupies more of the left side than it does in the adult. Indeed it is nearly equally balanced in the fœtus, but the older the animal (at least during the first five years) the greater will be the proportion of it found in the right side.

Without going into the more minute subdivisions of this viscus, we may observe, that it is more uniform and smooth, and convex on the upper surface; on the lower, more irregularly concave. Its upper surface is applied in close contact to the concavity of the diaphragm, and in the fœtus its margin is in contact with the abdominal muscles, because it falls lower than the margin of the ribs. Its lower and concave surface receives the convexity of the stomach, duodenum, and colon. In a healthy adult subject the liver does not extend from under the margin of the ribs, unless near the pit of the stomach, but in the fœtus and child it is much otherwise. In a fœtus of the third and fourth month the liver almost fills the belly; it reaches to the navel, covers the stomach, and is in contact with the spleen. After the seventh month, other parts grow with a greater rapidity in proportion. Indeed some have affirmed, that the liver, or at least the left lobe, actually decreases towards the time of birth.* But from this time to the advance to manhood the chest becomes deeper; the sternum is prolonged; and the diaphragm becomes more concave; so that the liver retires under the margin of the ribs, and its edge on the left side in the adult reaches no farther than to the œsophagus. When the liver becomes scirrhous and enlarged, its hard margin comes down so as to be felt through the abdominal pariës under the border of the chest. This enlargement of the liver, and consequent descent of its margin, is to be felt more easily by grasping the integuments of the belly, as if you expected to lift up the acute edge of the liver, than by pressing with the point of the finger. By this means we shall be sensible of the elasticity and softness below the liver, and of the resistance and firmness of the margin of it. The physician, however, should not forget, that the depression of the

* M. Portal, Acad. de Sciences, 1773.

diaphragm, and consequent protrusion of the liver by disease in the thorax, gives the feeling of an enlargement and hardening of the liver. The left great division of the liver is perhaps as often diseased and enlarged as the right, in which case it is more difficult to ascertain it by examination.

Neither should a physician be ignorant, that by suppuration in the lungs, and consequent rising of the diaphragm, the liver is elevated considerably, so as to retire farther under the protection of the false ribs.

M. Portal, by running stilettos into the belly of the subject as it lay upon the table, or was raised into the perpendicular posture, found that in the latter posture the liver shifted two inches. But it is almost superfluous to remark concerning these experiments, that they are by no means conclusive. In the dead body the abdominal muscles are relaxed; they yield to the weight of the viscera; and the diaphragm is pulled down by the weight of the viscera. The margin of the liver necessarily falls lower, but in the living body there is a close and perfect bracing of every part by the abdominal muscles; they do not yield, and very little if any alteration can take place in the situation of the viscera.

It must be observed, however, that a considerable motion of the liver is a consequence of respiration, and of the action of the diaphragm. This motion is chiefly on the back part of the right lobe of the liver. The left lobe being more on the centre of the belly, and consequently opposite to the centre and less moveable part of the diaphragm, it is less affected by the respiration than the larger right lobe.

LIGAMENTS OF THE LIVER.

The peritoneum is reflected in such a manner from the neighbouring parts upon the liver as to form membranes receiving the name of ligaments. It has been explained, however, that these are not the sole support of this viscus; and that the compression of the surrounding abdominal muscles is the principal support of the liver, as it is of the other viscera.

The BROAD LIGAMENT* of the liver is formed by two lamina of the peritoneum, connected by their cellular membrane, descending from the middle of the diaphragm and point of the sternum to the convex upper surface or dorsum† of the liver. This ligament is broadest where it passes down from the point of the sternum to the fossa umbilicalis; but as it retreats back-

* Ligamentum latum suspensorium, falciforme.

† See Plate I. of this volume.

ward it becomes narrower, and is united to the coronary ligament near the passage of the vena cava. This circumstance with the curve which it naturally takes on the surface of the liver, gives it the shape of the falx.

Ligamentum teres. The round ligament of the liver is the firmer ligamentous cord, which may be traced from the umbilicus along the peritoneum into the duplication of the broad ligament, and into the fossa umbilicalis. It is formed by the degenerated coats of the great vein which brings the florid blood from the placenta into the veins of the liver, and from thence into the right side of the heart of the fœtus.*

The coronary ligament of the liver is formed in consequence of the attachment of the liver to the diaphragm. The attachment is of course surrounded by the inflection of the peritoneum from the diaphragm to the liver. It is called the coronary ligament, though it has been observed, that this attachment of the liver is not circular, but of an oval and very oblong shape.

The lateral ligaments are formed by the peritoneum continued laterally. The right lateral ligament, like a mesentery, attaches the right and great lobe of the liver to the diaphragm, and the left lateral ligament connects the left lobe with the diaphragm, and with the œsophagus and spleen.

FORM AND DIVISIONS OF THE LIVER.

The liver is convex and smooth on the upper surface; concave and more irregular on the lower part; thick and massy behind and towards the right side; but anteriorly and toward the left side it is thin, and has an acute edge, so that it lies smooth over the distended stomach.

Great right and left lobes of the liver.—The first great division of the liver is marked on the convex surface by the broad ligament; which running back from the fossa umbilicalis divides it into the two great lobes, the right and left. When the concave surface of the liver is turned up, we see the same division into the right and left lobes by a fissure which runs backwards.

It is on this lower surface of the liver that we have to mark the greater variety of divisions in this viscus. Farther, it is on the right lobe that those eminences are to be observed, which, with the indentations and sulci, give some intricacy to this subject.

* See vol. ii. p. 171, and plate, p. 173.

Lobulus Spigelii.*—The lobulus Spigelii is betwixt the two greater lobes, but rather belonging to the right great lobe. From its situation deep behind, and from its having a particular papilla-like projection, it is called lobulus posterior, or papillatus. To the left side it has the fissure for the lodgment of the ductus venosus; on the right the fissure for the vena cava; and above, it has the great transverse fissure of the liver for the lodgment of the cylinder of the porta: obliquely to the right, and upwards, it has a connection with the lower concave surface of the great lobe by the processus caudatus, which Winslow calls one of the roots of the lobulus Spigelii. Its situation is within the circle or bosom of the lesser curve of the stomach.

Lobulus caudatus.†—This really deserves the name of processus caudatus, for it is like a process of the liver, stretching downward from the middle of the great right lobe to the lobulus Spigelii. It is behind the gall-bladder, and betwixt the fossa venæ portarum and the fissure for the lodgment of the vena cava.

Lobulus anonymus‡ is the anterior point of the great right lobe of the liver: or others define it to be that space of the great lobe betwixt the fossa for the umbilical vein and the gall-bladder, and extending forward from the fossa for the lodgment of the porta, to the anterior margin of the liver. Sometimes there is a projecting lobe on the margin of this part of the liver, and also there occurs a small projection on the left great lobe which acquires the name of lobulus lobi sinistri.

Sulci, and depressions of the liver.—On the lower surface of the right lobe there may be observed two slight excavations, formed as it were by the pressure of the colon and of the kidney. On the lower surface of the left lobe there may also be observed depressions answering to the convexities of the stomach and colon. But these are only the slighter irregularities which might pass unnoticed. There are, besides these, deep divisions which pass betwixt the lobes and lobuli, and indeed form these eminences.

Umbilical fissure.§—From the anterior point of the two lobes there passes backwards to the left side of the lobulus Spigelii a deep fissure, which in the fœtus gives lodgment to the umbilical vein, and which in the adult receives the round ligament, where it is about to terminate in the left division of the vena portæ. The back part of this fissure gives lodgment

* *Lobulus posterior—posticus—papellatus.* † Processus caudatus.
‡ Lobulus accessorius—anterior—quadratus.
§ Horizontal fissure, fossa longitudinalis, longa, anterior.

to the ductus venosus in the fœtus. This fissure divides the liver into its two right and left divisions, and upon the right side joins the transverse fissure.

The TRANSVERSE FISSURE is that which passes above the lobulus Spigelii and lobulus quadratus; the processus caudatus, and the lobulus lobi sinistri. It is in this fissure that the great transverse division of the vena portæ lies.

The POSTERIOR FISSURE* gives lodgment to the ductus venosus. It is a division in the posterior margin of the liver betwixt the left lobe and the lobulus Spigelii, and great lobe on the right. Sometimes, instead of the fissure or sulcus, there is a canal, as it were, in the substance of the liver.

The fourth great fissure, is that for the lodgment of the vena cava. It sometimes is called, in contradistinction to the last, the right fissure, or the FISSURA VENÆ CAVÆ. It is a large deep division betwixt the lobulus Spigelii and the back part of the right lobe, for receiving the vena cava as it passes up upon the spine.

The gall-bladder being sunk in the substance of the liver, the pit or excavation which receives it has been considered improperly as a fissure or fossa.† There likewise occur irregular fissures in the substance of the liver, which are like the cuts of the knife, and hold no regular place.

OF THE VESSELS OF THE LIVER, AND OF THE CIRCULATION OF THE BLOOD THROUGH IT.

THERE belong to the liver five distinct systems of vessels: these are, the vena portæ; the arteria hepatica; the venæ cavæ hepaticæ; the lymphatics; and the biliary ducts.‡ These, with the nerves, form a very intricate system of vessels, but a lesson of the most particular importance to the physician. Before speaking of the connections which these vessels constitute with particular parts, or with the entire system, we shall take a view of their origin and course.

THE VENA PORTÆ.

THIS vein is divided into two parts; that which belongs to the intestines, and which, ramifying on the mesentery, receives

* Or sulcus ductus venosi, the left fissure.

† It is generally called, *fovea fellis*, or *vallicula vesiculæ fellæe*.

‡ And we might add, the arteries of the outer membrane of the liver which arise from the internal mammary, phrenic, epigastric, and even the spermatic arteries.

the blood of the mesenteric arteries; and that part which branches in the liver, and distributes there the blood which it has received from the arteries of the membranous viscera. Even from this division, we see that the vena portæ has a very particular distribution; that while it is collecting its branches from the spleen, stomach, and intestines, like the veins in the other parts of the body, into a trunk; this trunk, instead of leading directly to the heart, or uniting with other veins in their course to the heart, enters the liver, and, like an artery, spreads into minute ramifications; hence it is called the vena arteriosa. It resembles an artery in this also, that it has no valves like other veins.

To be more particular; the vena portæ takes its origin from the extreme branches of the cœliac, upper and lower mesenteric arteries. The roots of the portæ answering to these arteries are the splenic veins; the gastro-epiploic vein which runs upon the great arch of the stomach; the mesenteric vein returning from the small intestines; and the right and middle colic veins, and internal hæmorrhoidal vein and left colic returning upon the mesocolon. These answering to the three great branches of the abdominal aorta, pass obliquely upward in three great divisions, and unite with some lesser veins, as the coronary and smaller veins of the stomach, and pancreatico-duodenalis. The trunk of the vena portæ is now involved in the irregularly reticulated web of the hepatic vessels, arteries, veins, glands, lymphatics, nerves, and biliary ducts, with their cellular membrane. It passes upward somewhat obliquely to the right; and enters the PORTA* or the sinus betwixt the processus caudatus and lobulus Spigelii.

When the vena portæ has entered the liver it divides into two great branches, which running directly transverse, and being of large capacity, are sometimes called the cylinder of the vena portæ. Of these two great branches of the vena portæ within the liver, the right is greater in diameter, but shorter:† it ramifies in the great right lobe of the liver. The left is longer considerably, and filling the tranverse fissure it is reflected up into the umbilical or horizontal fissure, and is given to the left lobe, to the upper and more anterior part of the right lobe, viz. lobulus anonymus, and to the lobulus Spigelii.

The minute ramifications of the vena portæ every where pervade the substance of the liver, and inosculate with the veins of the surface belonging to the peritoneal coat. The

* Sometimes it has been found divided before entering the liver. It has been also found to divide into three branches, in which cases, says Haller, two go to the left side.

† Into this branch sometimes the vein of the gall-bladder enters.

blood of the vena portæ is received into the extremities of the venæ cavæ hepaticæ.

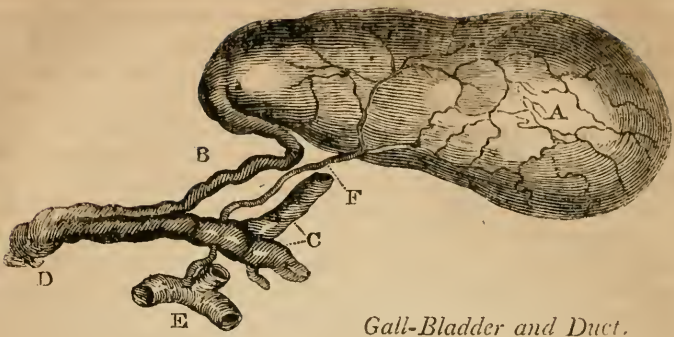
ARTERIA HEPATICA.

For the course of this artery from the root of the cœliac artery, to its entrance into the liver, see the description of the arterial system. The arteria hepatica and the venæ portæ are supported by the same sheath, the lesser vessel encircling the greater, like a tendril. While they have distinct functions, both terminate in the same returning veins: that is to say, whether we admit that one or both open into the biliary ducts, yet they have the same relation to the venæ cavæ hepaticæ which the arteries of the other parts of the body have to their returning veins.

VENÆ CAVÆ HEPATICÆ.

We have seen, that the right auricle of the heart is close to the diaphragm above, and that the liver adheres to the lower surface of the diaphragm. We have also found that there was a groove in the back part of the liver for the transmission of the vena cava abdominalis. Now as the vena cava ascending from the lower parts of the body to the heart is perforating the diaphragm, it is joined by two large veins from the liver, which, from their size and form, being the returning veins of the liver, are termed in general the venæ cavæ hepaticæ. These veins sometimes pierce the diaphragm together with the cava abdominalis, so that there is to be observed one large perforation in the diaphragm; but generally they pass the diaphragm close to the great vein, but so that there are three openings in the diaphragm. When these hepatic veins are traced into the substance of the liver, they are seen to be gathered together from all parts of the liver in two, or sometimes three great branches.

The communication betwixt the véna portæ and the venæ cavæ hepaticæ are so free, that several anatomists have imagined a peculiar and more immediate communication of their branches than holds in other parts of the body betwixt the arteries and veins; a circumstance which appeared to them the more necessary, considering the lesser impetus with which the blood flows in the vena portæ than in the arterial system.



Gall-Bladder and Duct.

BILIARY DUCTS.*

The smallest subdivision of the substance of the liver is called acinus, and that molicule is supplied with a branch of the venæ portæ, arteria hepatica, and venæ hepaticæ. With these there is also seen a minute ramification of the excretory duct of the liver. These last minute branches are the roots of the biliary duct; for they, running into each other, form trunks resembling the branches of veins, and these attaching themselves to the vena portæ form the greater trunks, answering to the right and left side of the liver. These two branches of the hepatic duct approaching each other, unite (C,) where they are attached to the right branch of the vena portæ. Their union constitutes the hepatic duct or ductus choledochus.

When the duct of the liver has advanced a little way from the transverse fissure, it is joined by the CYSTIC DUCT (B,) or perhaps we should rather say, considering the use of the cystic duct, that it is reflected from the hepatic at an acute angle to the right side. The DUCTUS CYSTICUS is much smaller than the hepatic duct, and is somewhat curved near the gall-bladder: it takes a very sudden turn downward, as is seen in the marginal plate.

The hepatic duct, after being joined by the cystic duct, con-

* *Explanation of the plate of the gall-bladder.*
A The gall-bladder.
B The cystic duct.
C The hepatic duct.
D The common duct.
E The hepatic artery.
F the cystic artery coming off from it.

tinues its course under the name of ductus communis choledochus, or common duct.* Now become somewhat larger, it takes its course under the head of the pancreas to the back part of the duodenum, about five inches from the pylorus.

Before it enters the gut, or more generally while included in the coats, it is joined by the pancreatic duct. Having pierced the muscular coat, it runs for some time in the cellular coat, in the length of the gut, and then opens upon the eminence of a considerable valvular plica of the inner coat.

This hole is regularly limited, and by no means equal to the diameter of the duct, either where it is contained within the coats of the gut, or in its course from the liver to the gut. Sometimes the hepatic and pancreatic duct open by distinct perforations.

The outer coat of these ducts is smooth and strong,† within this a cellular and nervous coat is described,‡ and muscular fibres imagined; but the inner coat is worthy of attention. It is reticulated in such a way, that a probe pushed up the duct is caught by their valve-like action.

GALL-BLADDER.

We have already noticed, that the gall-bladder is attached to the lower surface of the right lobe of the liver, and partly buried in its sinus: it has sometimes occurred that it was merely suspended to the liver by a membrane like a mesentery. It is a bag of a pyriform shape; its greater end or fundus is contiguous to the colon; its lower end or neck to the duodenum.§ It is generally of a size to contain an ounce, or an ounce and a half, of bile.

The coats of the gall-bladder are the outer peritoneal coat; a middle cellular coat, what from its analogy to that of the intestines we should call vascular coat; and an inner coat. In the intermediate coat muscular fibres have been looked for with great eagerness, but none have been demonstrated, although a conviction remains that there are muscular fibres in the composition of the coats of the gall-bladder. This coat gives form, limit, and strength to the gall-bladder. The third

* Ductus choledochus, hepatico-cysticus, (D.)

† Although this coat resists in a considerable degree the distention of the duct, when blown into or injected, yet the whole are sometimes so distended as to admit the thumb. But this is rather to be considered as growth and enlargement, than distention.

‡ By Haller.

§ The gall-bladder has been observed wanting; in which case the dilated ducts would seem to have been capable of retaining a quantity of bile ready to be evacuated into the intestine. A double gall-bladder has sometimes been found.

or inner coat is formed into innumerable rugæ, so as to take a cellular or reticulated texture. These loculi, as we may call them, thus formed by the duplicature of the internal membrane, are of considerable variety in shape, square, round, or triangular. These rugæ, and the whole internal membrane of the gall-bladder, have a beautiful and minute net-work of vessels upon them; and in these cells there can be little doubt that there are small mucous follicules or pores, or that an exudation from extreme vessels, sheaths the surface from the irritation of the acrid bile. The extreme degree of vascularity and reticulated texture of this inner coat of the gall-bladder is not apparent before the sixth or seventh month of the fœtus, and then it takes a peculiar texture in preparation for the reception of the secreted bile.

Towards the opening of the bladder into the cystic duct the rugæ assume a semilunar figure, and seem to have a valvular action, in at least so far that they seem intended to give a degree of difficulty to the passage of the bile. The same structure of the internal coat prevails in the cystic duct.

However strange it may appear to one, considering the relation of the liver as a gland to its ducts, and to the gall-bladder as a receptacle of the bile, an opinion was entertained that the bile of the gall-bladder was secreted by its own coats, and that it was of a different nature from the bile conveyed from the substance of the liver. Without further argument it is sufficient to say, that when the cystic duct is tied, or when it is preternaturally obstructed, there is no bile secreted into the gall-bladder.

From the connections of the gall-bladder, and from the considerations of the whole anatomy, there can remain no doubt that the gall-bladder is a mere receptacle, reserving a sufficient store of this fluid for the due change to be performed upon the food: that as the stomach is not at all times loaded with food, nor the chyme and fluid from the stomach incessantly passing through the duodenum, neither is the bile at all times running from the gall-ducts. On the contrary, as the stomach is emptied of its contents at stated intervals, the gall-bladder affords a provision for a quantity of bile to be evacuated proportioned to the food, which is passing the duodenum. Whether we should conceive that this is a necessary consequence of the retention of the bile in the gall-bladder, or a wise provision of nature, I am uncertain; but it appears, that the longer the bile is retained, or the longer the fast and the deficiency of food in the duodenum, the more acrid and inspissated is the bile, and the greater also in quantity. This inspissation of the bile takes place in consequence of the activity of the lymphatics, which ramifying on the coats absorb the thinner part of the bile.

The rugæ of the inner coat of the gall-bladder may be a provision for extending the surface either for absorption or secretion; but I rather imagine that they are merely a provision for permitting extension more freely.

The gall-bladder is supposed by some to be emptied by the general pressure of the abdomen; an opinion founded on a mistake, which a very little consideration might correct. Others think that the stomach, or duodenum, or colon, being distended by the food, compress and empty the gall-bladder; while others with more apparent correctness allege, that it is emptied in consequence of a consent of parts. With the latter I would confidently affirm, that as the aliment passes the duodenum, the bile follows apace, either from the alternate contraction and relaxation of the duodenum occasioning a relaxation of the orifice of the ducts, or more probably from the ducts being excited, as the salivary glands are excited by the presence of sapid bodies in the mouth. By want and hunger, on the contrary, the gall-bladder is allowed to be distended: there is no call for its evacuation.

Experiments would even teach us, that the gall-bladder has not the same irritability excitable by stimuli applied to the coats, which the stomach, intestines, or bladder of urine have; which is a proof that, like the iris, and many other parts of the body, its action is roused more powerfully by the indirect stimulus and through consent of remote parts, than by the distention of its coats; whereas the intestines and bladder have it in their constitution to be excited to contraction by simple distention.

From experiments it would appear, in confirmation of what is here alleged, that while the food is in the stomach, little bile is discharged; but that it flows when the matter is passing the duodenum, so that a great quantity is then found in the gut. On the contrary, in a state of want and hunger, the gall-bladder is greatly distended, and yet little bile flows from it; although it is not only more accumulated, but more acrid and bitter.*

That the gall-bladder is not destitute of irritability and the power of contraction, would appear from many cases, where, like the urinary bladder, it contracts upon concretions, and becomes thick in its coats.

The retention of the bile, surcharging the ducts, and distending the gall-bladder, and the sudden discharge of accumulated bile, and the irregularities of its course when influenced

* Anat. générale de Xav. Bichat, tom. iv. p. 6.

by disorder of the viscera, are the source of the most severe and distressing symptoms.*

In the dead body we see the colon and duodenum, or whatever parts lie in contact with the gall-bladder, stained with bile; but this evidence of transudation which is found in the dead body, is not seen in the living, while the stain from the bile is observed to be deeper and more extensive in bodies long dead. It is therefore another example of the peculiar properties inherent in the living fibres, that no transudation is allowed;† but that the fluids, which appear as if exuding from the living surfaces, are really discharged from organic pores, or from the extremities of vessels.

OF THE MINUTE STRUCTURE OF THE LIVER.

The liver is firmer and drier in some degree than any of the other viscera; the intertexture of membrane is weak, and in consequence the substance of the liver is friable and easily torn. When cut or torn, it seems for the greater part vascular: or it displays the mouths of innumerable ducts and vessels, and, after a minute injection, the blood-vessels seem to pervade every particle, even when examined with the microscope.

This texture of vessels, in which we may say the substance of the liver chiefly consists, is surrounded with a delicate membrane, the continued peritoneum. It retains the character of peritoneum, in being a simple membrane, whitish, and a little pellucid. In this membrane minute arteries and veins ramify, which are unconnected with the internal system of the vessels, and in the close cellular membrane beneath it the lymphatic vessels take their course.

When a section is made of the liver, the vessels may be thus distinguished: the ducts by the thickness of their coats, and their yellow colour; the arteries by a less degree of thickness, and a more resisting elasticity; the branches of the vena

* We have example of this in a Treatise on the Diseases of the Bowels of Children, by Dr. Cheyne.

† The peculiar odour of the intestines of a dead body is not perceptible in the living; when in dissection the fingers touch the intestines, they retain the odour long: but on handling the intestine in the operation for herniæ, the bad smell does not attach, nor is it at all perceptible. Poison in the stomach of an animal will pervade the coats and affect the whole substance, if permitted to remain after death: but if the stomach containing the berries of the laurus cer. be taken from the pheasant of America, they are wholesome food. The peccary, or Mexican hog, when killed, must have the dorsal gland immediately cut out, or the disagreeable smell of this secretion makes the flesh unfit to be eaten. For the same reason the Indians cut away the noxious glands from the skunk immediately when killed. All these examples show that the living substance resists the contamination, but that when the parts are dead they no longer resist the percolation of the fluid, the colouring or odorous matter.

For much of the anatomy of the liver, and of the bile, see Morgagni Adversar. An. iii. A. xx. to xxvii.

portæ and the cava hepaticæ by the thinness of their coats, of which those of the latter are considerably the weaker.

With the investiture of the peritoneal coat of the liver even the vascular tissue of the body of the liver has no communication by vessels.* It is therefore considered as a peculiarly distinct organization. By the proofs from anatomical injections we are informed, that there is a free intercourse through the extreme branches of all the five systems of vessels in the liver. By making minute injections, and sections of the liver, there seems no likelihood of gaining information of the structure and connections of these vessels. Walther, who seems to have examined more methodically and minutely than any other anatomist in any age, could make no distinction of parts. In whatever way he made his sections, whatever system of vessels he filled, whether the whole vessels or each separately, he could not ascertain the direction and course of any particular vessel, nor its inosculations, but all was obscure, and as if constituting one chaotic mass. In wet preparations, however, he observed, that the extreme branches of the hepatic artery opened into the vena portæ: that the branches of the vena portæ had a double termination: that some of them, by a sudden turn and serpentine course, terminated in the branches of the venæ cavæ hepaticæ;† while others were seen to terminate or open into the biliary ducts. Further he observed, that in all the branches of the vena portæ there was a peculiar compressed appearance which distinguished them from all the other vessels of the viscus.

There have been observed intersections of the intimate membrane of the liver, which divides and subdivides the fasciculi of vessels. These are, however, somewhat obscure and indistinct. The last perceptible subdivisions of the substance of the liver have been called ACINI‡; and they are rather presumed than directly proved to have in their composition an extreme ramification of the several vessels of which the liver consists.§

We have seen that Malpighi conceived that these bodies were simple glands collected on the ramifications of the vessels; that they were little vesicles; and that from them the pori biliarii took their origin. In this opinion he was successfully opposed by Ruysch, who affirmed that they were vascu-

* Soemmerring. Walther, loc cit. &c.

† I should imagine that in this he might have been deceived by the lesser branches of the portæ (filled with injection) opening into the side of the larger trunks; and that there is no such termination of the hepatic arteries in the sides of the vena portarum, so that their open mouths are discernible.

‡ See the definition in the introduction to the anatomy of the viscera.

§ Acinos nemo rejicit, ne Ruyschius quidem, sed de interior fabrica disputatur. *Haller.*

lar; and in this opinion he has been supported by Albinus. It would in truth appear, that the description of these partitions of the substance of the liver, and the ultimate subdivision of it into these little grains, about which there has been so much controversy, is not founded in an accurate observation, and that there are neither cryptæ, hollow and cellular, nor little bodies made up of convoluted arteries, but the minute parcels of vessels, which are collected together and united by fine cellular texture; they may be called acini, according to the definition which has been given in the introduction.*

OF THE FUNCTION OF THE LIVER, AND OF THE SECRETION OF THE BILE.

NOTWITHSTANDING that the circumstance of the biliary duct being discovered points to one very obvious use of the liver, yet I am not satisfied that our knowledge of its functions is nearly perfect. In animal bodies one organ ministers to several functions. As the tongue is the organ of taste, of speech, of deglutition; as the lungs minister to respiration, to circulation, to speech, to smelling; as the skin serves many purposes, so I believe that we are too easily satisfied with discovering one use of the liver in secreting the bile and stimulating the intestines.

The great size of this gland would impose upon us the belief that it serves some very important use in the animal economy, and the state of the system which originates with the disorder of the biliary secretion strengthens that belief. The function which it performs is probably the separation of some form of useless carbon; as M. Fourcroy has taught, that the bile is formed in a great measure of the combustible matter of the blood, thus making the liver a true auxiliary of the lungs.

Upon reviewing the whole system of the liver the peculiarities in the vena portæ strike us the most. It occurs to us that this great supply of blood to the liver, with the slow motion peculiar to venous blood, after having gone the circulation through the intestines, is a provision for the discharge of car-

* Finally, Ruysch's opinion may be given in these words: (Epist. ad Virum Clar. Ner. Boerhaave, p. 69.) "Sed nolo diutius tergiversari, fateor ergo, quod, quando primo incipiebam me exercere in anatomicis, videbam tunc quidem, quod in jecore humano se ostendebant acinuli parvi innumerabili numero, quæ tum temporis appellabantur glandulæ; nam nemo cogitabat aliter sed manet sola jam hæc questio, an acinuli hi hic herentes sint glandulæ simplicissimæ, foliculi cavi cum emissario an quid aliquid? dico nemo demonstravit illos tales esse ut hic assumis. Imo vero facile jam erit demonstrare, acinos hos cum criptis antea pertractis nihil commune habere: quia oculis nostris non apparent ut membranulæ cavæ & quia etiam non habent emissarium. Sed componuntur tantum ex extremitatibus ultimis vasculorum sanguiferorum unitis in formam spheræ rotunditatis, neque, quantum possum videre etiam membranula aliqua sua singulari circumambiuntur."

bon and for the secretion of the bile. It is believed, that the secretion of bile is made from the blood of the vena portæ.

But as we see that this blood distributed by the branches of the vena portæ in the liver must be so far exhausted as to become incapable of all the uses accomplished by the arterial blood in other glands, that although the vena portæ be peculiarly adapted to secrete the bile, it is not capable of supplying the nutrition and the energy to the substance and vessels of the liver, there is a necessity for arterial blood being sent to this gland through a branch of the arterial system. We have had occasion to remark, that no part retains its functions in vigour, nor the living properties which are inherent in it, while the whole economy is entire and correct, unless the arterial blood be circulated through it. Therefore it would appear necessary that the arteria hepatica, a branch of the aortic system, should also be bestowed upon this viscus. These arteries perform the same office here in the liver that the bronchial arteries do in the lungs, or the coronary arteries in the heart, or the vasa vasorum in the great vessels. The pulmonic artery carries venous blood into the lungs, which having returned from the circulation of the body, cannot send off smaller branches to supply the membranes and vessels of the lungs; it is necessary that for this purpose branches of the aortic system shall enter the lungs. Again, in the heart the blood contained in its ventricles is incapable of supplying its substance; or the blood coming through the canals of the great vessels cannot be the means of ministering to the active powers of their coats: but for this purpose the vasa vasorum are distributed through the coats of the vessels. These vessels therefore bear an analogy to the arteria hepatica in the liver.

We must not however suppose that this scheme of the action of the vascular system of the liver, however rational and simple, will be universally allowed. Indeed there are circumstances which seem to stand in opposition to it. Of these, the most interesting is the case of unusual distribution of the vessels of the liver communicated by Mr. Abernethy.

The subject was a female infant which was supposed to be about ten months old. Among other varieties it was observed, that the branch of the cœliac artery distributed to the liver was larger than common, and exceeded by more than one third the usual size of the splenic artery. This was the only vessel which supplied the liver with blood for the purpose of either nutrition or secretion. The vena portarum was formed in the usual manner, but terminated in the inferior cava nearly on a line with the renal veins. The liver was of the usual size, but had not the usual inclination to the right side of the body: it

was situated in the middle of the upper part of the abdomen, and nearly an equal portion of the gland extended into either hypochondrium. The gall-bladder lay collapsed in its usual situation. It was of a natural structure, but rather smaller than common. On opening it there was found in it about half a tea-spoonful of bile. The bile in colour resembled that of children, being of a deep yellow brown, and tasted like bile, but it was not so acridly bitter and nauseating as common bile.

Mr. Abernethy remarks upon this case, that when an anatomist contemplates the performance of biliary secretion by a vein, a circumstance so contrary to the general economy of the body, he naturally concludes that bile cannot be prepared unless from venal blood; and he also infers, that the equal and undisturbed current of blood in the veins is favourable to the secretion; but that the circumstances of this case, in which bile was secreted by an artery, prove the fallacy of this reasoning.*

We may further observe on this case, that it does not prove the bile to be the natural economy, secreted by the arteries and not even by the vena portæ; for the artery here was unusually large, so that it performed a function in this instance which it does not usually perform. On the contrary, had the artery been of the usual size, we might then have concluded that the vena portæ was distributed to the liver to serve some lesser use in the èconomy of the system, and that it did not secrete the bile.

The liver, it is said, was of the ordinary size. Now as the bulk of the liver is, in its natural state, made up of the dilated veins, it is some proof of what I should imagine had taken place here, that by some provision of the vessels the arterial blood had been diffused, and the celerity of its motion checked previous to its ultimate distribution. Nay, it may have opened into the branches of veins answering to the extremities of the vena portæ.

In the deficiency of the acrid and bitter state of the bile, there is in this case evidence that the bile formed from the arterial blood is unlike the perfect secretion. I conceive this opinion to be countenanced by the peculiar circulation of the blood in the liver of the fœtus, and by its effects upon the secretion. We have seen in the fœtus, that almost the entire gland is supplied with arterial blood returning from the umbilical vein; and the natural deduction from this is, that this is the cause why the bile in the fœtus is of a less stimulating quality, and smaller in quantity than in the adult.

* See Mr. Abernethy's case of uncommon formation of the liver. Phys. Transactions.

I conclude, that this singular and interesting case may strengthen the opinion which some have entertained, that the extreme branches of the hepatic artery pour blood into the extremities of the vena portæ previous to this formation of the bile by these veins; but it still leaves us with the general conclusion, that the peculiarities in the distribution of the vena portæ are a provision for the secretion of the bile, and that the branch of the aortic system, the hepatic artery, is otherwise necessary to the support of the function of the liver.

Finally, as to the use of the liver independently of the secretion of the bile, we must lay aside the opinions mentioned by Haller, that it supports the diaphragm, pushes it up in expiration, and receives the contraction of it equally in inspiration, so as uniformly to compress the other abdominal viscera; or that it foments and cherishes the stomach by the heat of its blood. These are at least as bad as the theories of the ancients mentioned in the beginning of this section. Haller sometimes puzzles us by the promiscuous admission of all facts and every kind of theory, with something of indecision in giving his own opinion.

There is another remark of Haller which deserves attention. When I reflect, says he, that there is no bile required in the fœtus, there being no food received: when again I see that the liver is of great size in the fœtus, and not small like the lungs, which are destined to an operation in the economy after birth, I cannot but suspect that it has some other use in the fœtus than the secretion of the bile. If the umbilical vein had opened directly into the cava, he thinks it would have returned with too great an impetus upon the heart, and would by its preponderancy have retarded the return of the blood from the lower extremities. He thinks that the liver is useful in breaking and weakening the impulse of the blood from the umbilical vein; that it is a guard to the right auricle, which would be otherwise endangered by the rapid flow of the blood. Now surely the liver is much less able to stand the impulse of the blood than the heart; and yet there is no provision for the breaking of the force of the blood in the liver. Further, there is a direct duct of communication leading to the heart. There is no reason to believe that the umbilical vein carries back the blood with greater force than any other returning vein: on the contrary, from its size and the length of its course it is natural to suppose the motion of the blood in it to be very slow and equable.

We must look upon the peculiarities in the circulation of the blood in the liver of the fœtus as a provision against the secretion of stimulating bile; for when the child is born and the

circulation altered, bile is formed more abundantly, and becomes the stimulus to the whole abdominal viscera, rousing them to new action. As to the comparison which Haller has made between the state of the liver and that of the lungs, it is evident that the latter, though small in bulk, are fully formed, and want only inflation to complete their function. In the liver of the fœtus the vessels are distended with blood, to give them the size requisite for this future function; but that blood, either from its qualities or from the easy and direct passage it has into the heart, does not secrete the bile of a quality to stimulate the ducts and intestines, as in the adult circulation. If it did, we should not see the alimentary canal of the fœtus loaded with green matter, and in a state of inactivity and torpor.

The natural bile of the adult system is of a deep yellow colour; when concentrated by the absorption of its liquid parts, it is brown; sometimes the bile of the gall-bladder is green, although there has been no disease in the liver to compare it with something familiar: the bile is of the colour of wetted rhubarb. As to the use of the bile, the more common opinion is that it precipitates the feculent matter from the chylous fluid. But for this there is no other foundation than that such a separation does actually take place; but we have bestowed that action on the villous coat of the intestine,—with what show of reason may be seen above.

Mr. Hunter was of opinion that this bile did not incorporate with the chyle; it certainly does not confer on that fluid its sensible qualities, though it may be possible, according to the opinion of M. Fourcroy, that the alkaline and saline ingredients of the bile may combine with the chyle, while the albumen and resin may combine with the excrementitious matter.

If the bile was a mere excretion, if it were poured into the intestines merely to be thrown off, then the duct would have entered into the lower part of the gut, and not into the duodenum.

Neither would we have observed that connection betwixt the state of digestion and the discharge of the bile into the intestine, which I have already noticed.

Perhaps we may conclude, that the liver linked in close sympathy with the intestines, connected by nerves, by blood-vessels, and by ducts, holds a control over their action by the stimulating fluids which it supplies to them.

SECTION II

OF THE PANCREAS.

The pancreas is a gland the largest of those which have been called the conglomerated, that is, distinctly consisting of lesser parts united. It is of a long form like a dog's tongue, and lies across the spine, and behind the stomach. Its excretory duct opens into the duodenum.

The pancreas is confined betwixt the two lamina of the mesocolon, and it is united to them by a loose cellular membrane; it lies before the great mesenteric vessels, with its posterior face upon the spine and aorta, and covered anteriorly by the superior lamina of the mesocolon. It is divided into the head, body, and extremity. The head is towards the right side: its small extremity touches the spleen, and is near the capsule of the left kidney: but towards the right extremity it increases gradually in massiness, until its head lodges upon the duodenum. It is like the salivary glands in its appearance, consisting of lobules successively smaller and smaller; and it also resembles them in the manner in which its duct is formed. The duct* begins towards the left extremity by exceedingly small branches: these running together form a middle duct, which taking a serpentine course towards the great extremity, and increased by the accession of the lateral branches in its course, becomes nearly of the size of a writing quill. Towards the right, the head of the pancreas is irregular, and indeed a lesser pancreas generally projects from it. Approaching the duodenum the duct unites to the biliary duct, and opens along with it into the duodenum. A valve has been described as in the extremity of the pancreatic duct, but it is certainly incapable of the action of a valve, as the bile has been found to have gone retrograde into the trunk of the pancreatic duct. Sometimes there are two pancreatic ducts, but more frequently the part of the gland next the duodenum, and which is called the round head of the pancreas, has an excretory duct peculiar to itself, which either opens into the duodenum separately from the main duct, by piercing the coats of the intestines nearer the stomach, or sometimes opens further down. In

* Ductus Virsungi.

the dog there are distinctly two ducts, the one opening into the biliary duct, the other separately into the duodenum.

De Graff, Ruysch, and many others, have made experiments to discover the nature of the secretion from the pancreas. Tubes were introduced into the ducts, and bottles were appended to them in living dogs, so as to catch the pancreatic fluid: it was found ropy, insipid, and like the saliva. It has therefore been concluded, from the colour, structure, ducts, and secretion of the pancreas having so strict a resemblance to those of the parotid and submaxillary glands, that it is of the nature of the salivary glands of the mouth. The general opinion has been, that it is useful in secreting a fluid which dilutes and moderates the acrimony of the bile. More accurate chemical examination of the pancreatic fluid has not been made, or has not been successful in showing any peculiarity in it.

Considering the pancreas as a salivary gland, how great must be the quantity of fluid poured out by it, if, as we are entitled to do, we take the analogy of the parotid, submaxillary and sublingual glands. These salivary glands, although they may be said to surround all the jaws from the zygomatic process on either side, are nothing in massiness and size to the pancreas. Again, the pancreas is most plentifully supplied with blood-vessels. Besides lesser branches of arteries, the pancreatico-duodenalis gives two branches, which take an extensive course through it, and are joined by other mesenteric twigs; and twigs proceed from the vessels of the stomach, and even from the hepatic artery; but more particularly we have to observe the large branches bestowed upon it by the splenic artery, where it takes its course close upon it.

While the masticators are working, the parotid gland pours out so great a quantity of saliva, says M. Helvetius, that it is inconceivable, and what I should not believe, had I not seen it in a soldier of the guards. A cut with a sabre in the cheek had opened the salivary duct: the wound healing on the inside of the cheek left a fistulous discharge from the parotid duct. When he eat, there flowed from this hole a great abundance of saliva: so that during dinner, which is not long in the Hotel Dieu, it moistened several napkins. How much must flow from all the salivary glands? How much from the pancreas, which is greater than them all collectively?

The pancreas being supplied with arteries from the splenic artery and duodenal artery, it must partake of the increased circulation of blood, while this system of vessels is excited by the fulness of the stomach. By this it must be prepared with

an increase of secretion proportioned to the food passing the pylorus.

Like the biliary secretion, it is probable that the contents of the stomach passing the duodenum, or the bile flowing from the biliary ducts, form the stimulus to the discharge of the pancreatic fluid; and as we see that the morsel in the mouth will quickly produce an almost instantaneous secretion and discharge of saliva, so we are led to conclude that the flow of pancreatic fluid may be as suddenly produced without the necessity of a reservoir, as in the biliary system. We naturally conceive that the effect of this fluid is to diminish the viscidity of the bile, and by diluting it to mix it uniformly with the food. There are however few facts to enable us to reason on the effects of the pancreatic fluid. If we give full credit to the experiments of Malpighi and Brunner we may conclude, that when the pancreas is taken away, the more acrid bile causes vomiting or voracious appetite by its stimulus. Scirrhus of the pancreas has been found attended with a costive and slow motion of the intestines; which seems to contradict the result of these experiments on animals; but by the scirrhosity and enlargement of the pancreas the biliary ducts may have been more or less compressed, and the retarding of the usual quantity of the biliary secretion might produce the slowness of the bowels.*

On the whole, I am inclined to think that the pancreas is a gland of dilution, merely that the flow of its secretion will depend on the state of the food or of the bile passing the duodenum. That, as in drinking, the saliva is not excited to flow, neither is the pancreatic fluid, when the matters descending through the duodenum are bland and liquid, but when they require dilution this gland is ready to afford it.

* According to the hypothesis of Silvius, the use of the pancreas was to supply an acid spirit or juice, and the biliary secretion being of the nature of an alkali, these two struggling together caused the separation of the chyle from the fæces. The struggle did not stop here, but these enemies being carried into the blood continued their warfare in the heart itself, and lighted up the vital flame there

Nay, if we believe the experiment of F. Schuyl, (de Veteri Med) this hypothesis was not without its proofs: for having tied in the portion of the duodenum of a living dog, where the pancreatic and biliary ducts enter, he saw the ebullition from this struggle of the acid and the alkali; and when he compressed the hepatic duct, the tumefaction of the intestine subsided; when he took off this compression it was again blown up. As this experiment has not succeeded since, as Haller observes, Schuyl was probably deceived by the peristaltic motion of the intestines.

SECTION III.

OF THE SPLEEN.

The spleen is a viscus of an irregular, oval figure, and dark purple colour. It is attached to the great extremity of the stomach. It is soft in its substance; and has the peritoneal coat very delicate. We should be glad could we say with the old anatomists that it is of a parenchymatous structure, for in truth little is known of its organization.

In treating of this subject we must be indulged in some speculation; and indeed it is privileged ground; for the history of the opinions regarding the supposed function of the spleen is full of loose conjectures or wild hypotheses, and nothing is as yet certainly known of its use.

SEAT AND CONNECTIONS.

The spleen is seated in the left hypochondrium; above the left kidney; and under the protection of the false ribs; and of course it is under the edge of the diaphragm. It is connected with the stomach by the cellular membrane, by the omentum, and in a still more particular manner by the vasa brevia. It has also connections with the left extremity of the pancreas by cellular membrane, and the branches of the splenic vessels. Lastly, it has a firmer attachment to the diaphragm, by means of a ligament formed by the peritoneum.*

The spleen is of an irregular figure. Where it is contiguous to the diaphragm it is uniformly convex: towards the stomach its surface, while it is hollowed out and concave, presents two sides, so that we say the whole mass is somewhat of a triangular form. The anterior edge of the spleen is notched with deep sulci; behind, and at the upper part, the margin is large and round.

The substance of the spleen is the most spongy, tender, and soft of all the abdominal viscera; so much so that not only does the finger make an impression upon its surface, but it actually disorders and tears its vessels.† After a successful injec-

* Yet the spleen is very apt to change its situation, or to fall down from under the protection of the false ribs. It is liable to enlargement. From which circumstances it will not be wonderful if it is wounded in tapping for the ascites. See Monro on Dropsy. Lienis a statu suo devirationes, Sandifort, Thesaur. Vol. iii. L. Baader observationes variæ. Albinus Acad. Annot. lib. vii. cap. xiv.

† I have seen death from rupture of the spleen, by a wound which never penetrated the abdomen; a pistol shot entered the chest and struck the diaphragm without piercing it; the lad died with effusions in the belly; and on examination, the spleen was found burst by the contusion.

tion the whole seems made up of vessels ; and if any thing like acini or globules are to be observed, the microscope will show them to be accidentally produced by the fasciculi of vessels. By injecting the vessels of the spleen with wax, and corroding it, granules of wax are seen on the extremities of the veins as if they had filled cells. The cellular texture uniting the vessels of the spleen, assume a remarkably stellated appearance. Upon the whole, this viscus has a resemblance to the substance of the placenta. The spleen is seldom smaller than natural; often greatly enlarged.* I have seen it equal to the liver in size, and filling the whole left side of the belly. It has been frequently found thus enlarged, without any peculiar symptoms indicating such a disease during life. From its soft texture and great vascularity, like the liver, it has been found rent by blows and falls ; and wounds here, as in the liver, by opening the large vessels, are suddenly fatal.† Sometimes it is hard and scirrhous ; it is subject to inflammation, to ossification, and to have tubercles formed in its substance. There is seldom suppuration in it. The spleen has been observed to swell up and enlarge when the stomach is empty, and to be contracted when it is full. It has been observed, that it is large and spongy in those who have died a lingering death, or who have been long ailing: that, on the contrary, it is smaller and firm in those who have died suddenly a violent death.

We are informed, that the blood of the splenic vein is peculiar, insomuch as it does not coagulate like the blood in the other veins of the body.‡

That which more than any other circumstance excites our attention, is the great size of the blood-vessels of the spleen. Both the splenic vein and the artery are of great size in proportion to the bulk and weight of the spleen ; and in their course they are particularly tortuous. I conceive we may also draw consequences from the distribution of their branches to the stomach (viz. the vasa brevia and left gastro-epiploic) and to the pancreas. Its lymphatics are numerous. It is supplied with nerves, but has very little common sensibility. It has no excretory duct.

Professor Coleman made experiments on dogs, and found that when they were deprived of the spleen they became fat and indolent. An old pupil has lately given me an account of his cutting off the spleen in a native of South America. The

* For Verities see Morgagni Advers. iii. Animad. xix.

† I have known a musket ball, striking the spleen but not penetrating the abdomen, prove fatal in consequence of extravasation.

‡ With regard to this point I have no opinion, having hitherto neglected to examine the fact. The experiments of Sir Everard Home countenance the opinion.

spleen escaping from a wound had become gangrenous. He could observe no effect to result from this extirpation.

Opinions regarding the use of the spleen.—Of the various uses of the spleen, the lowest conjecture in respect to ingenuity or probability is, that like a sand-bath it foments the stomach, and promotes the process of digestion. This notion is, perhaps, not inferior in absurdity to that opinion which ascribed to the spleen the office of forming an acid juice, which being carried by the vasa brevia into the stomach, was supposed to excite the appetite.*

It was a better conception that the spleen is the seat of melancholy; "that moping here doth hypochondria sit:" or of "laughter holding both his sides," of which the holding of the sides was an evidence. And again, since tickling the ribs is a demonstration of the effect from this excitement of the spleen,† that the growth of the spleen promotes laughter to such a degree, that it becomes a permanent silly simper. Nay, further, we have authority for the excision of the spleen from those who are otherwise incurable in their propensity to laughter!

The following is a theory which has been very commonly received. A great quantity of blood is imported into the spleen with a slow motion, owing to the serpentine course of the vessels. When the stomach is empty, the blood is received in a greater quantity by the spleen, where it has an opportunity of stagnating. Here the blood, fomented, attenuated, and in a manner dissolved by the neighbourhood of the putrid fæces in the colon, enters upon the first stage of putrefaction. By this resolving of the blood it is made more fluid, in which state it is returned by the veins, there being no excretory ducts. Now when the spleen is compressed between the distended stomach and the ribs, and the contracting diaphragm, the blood is pressed out from it in greater quantity and celerity towards the liver, mixing with the sluggish blood in the trunk of the vena portæ, replenished with the fat and oil of the omentum, it dilates that vessel, and prevents the stagnation and congelation of the blood. In short, the spleen has been supposed to be subservient to the function of the liver, and to the preparation of a watery (and sub-alkaline) fluid to the blood of the portæ.

* I am mistaken in calling this the lowest in absurdity. The spleen has been considered as the seat of the soul! the cause of venereal appetite! the gland which formed the mucilaginous fluids of the joints! The atrabilis was received here, concocted and transmitted to the liver. It drew forth and formed blood from the stomach, &c. Other physiologists, not contented with the theories presented to them, and yet incapable of suggesting others more likely, have very modestly asserted that the spleen was of no use at all.

† Risus in liene sedes videtur ex effectu titilationis nataque in plurimis mortalibus risum excitat, &c. Haller. His sober objection is, that tickling the right side will do as well as the left.

Another opinion has been, that it counterbalanced the mass of the liver seated to the right side of the belly.

Hewson entertained a theory regarding the use of the spleen which is injurious to his reputation. He conceived that the spleen added the flat vesicle of the globules of the blood: his only observation in way of proof was, that he saw a few red globules returning by the lymphatics of the spleen; the effect, I have no doubt, of the injury of its substance, or if the compression of its vessels. It seems to me strange that such a man seeing the large splenic artery throwing its full tide of perfect arterial blood into the spleen, full of globules, complete in every respect, and again seeing a few globules carried back by the lymphatics, should imagine that this artery formed these few vesicles with which it was already so fully charged.

That the stomach, duodenum, liver, pancreas, and spleen are united in function, I have no doubt. Nature has placed them not only in juxta position, but has united them by the same entanglement of nerves, and has given them the same system of vessels. The cœliac trunk supplies them all.

Further, I conceive the spleen to be an organ subservient to the stomach; and not only the constant attachment of it to the stomach in the human body, but the constancy with which it is found connected with the stomach in the lower animals, confirms the opinion. I regard it as a provision for giving the vessels of the stomach an occasional power and greater activity, enabling them to pour out a quantity of fluid proportioned to the necessity of the digestion. In the first place, let us examine the course and form of the splenic artery, and I think we shall find the great peculiarity of its size, and tortuous form and strong coats, a provision for occasional great increase of power; while, if not roused by the peculiar sympathies which actuate it, it is of a form to retard and weaken the velocity of the blood. This is founded on these propositions:

1. The muscular power of an artery increases as it recedes from the heart; the elastic power diminishes.

2. An artery, the nearer it approaches to its final distribution, is the more immediately under the excitement and control of the organ; is active when the organ is excited; is, relatively speaking, quiescent when that organ is not called by its sympathies to exercise its function.

3. An artery tortuous in its course has more muscularity and greater power of action than one which takes a straight course: but in proportion to the increase of power which it obtains by its increase of length in this tortuous and bending

course, will these turns retard and weaken the force of the heart upon the extreme ramifications of the vessel.

Thus a tortuous artery is the means of increasing the velocity of the blood by its own action, but it makes the organ less dependent on the general force of the circulation. We accordingly find, that in those organs where there is occasional activity alternating with a quiescent state, the artery is tortuous; and where there is an increase of force required in the circulation, there the artery, from being straight in its course, becomes crooked and twisted in every way.*

From these remarks, we may be inclined to draw, from the tortuous figure of the splenic artery, a conclusion somewhat different from that which has hitherto been deduced. We may conclude, that it is not the means of retarding the blood in its circulation, but of giving force to it. The splenic artery does not only ramify in the spleen, but it supplies all the left part of the stomach, and that great sacculated extremity in particular which receives the food, and in which the process of digestion is chiefly performed. My idea is, that when the stomach is empty, when there is no food in it to solicit the discharge of the gastric fluid, the blood circulates in a moderate degree in the coats of the stomach, and the spleen receives the surcharge of blood; but when a full meal is taken into the stomach, when the action of the gastric juice is required in great quantity, the action of the splenic artery is solicited to the vasa brevia and left gastro-epiploic artery, and thus a sudden flow of the gastric fluid is bestowed by the increased activity of the splenic artery. When again the contents of the stomach are fully saturated with the fluids from its coats, there is no longer an excited action of the splenic vessels, and the artery terminating in the veins, the spleen returns the blood to the liver. While the vessels of the stomach partake largely of the supply of blood, the arteries to the pancreas also receive some increase of activity; and even the blood of the vena portæ requires an additional activity.

I leave this opinion of the vascular system of the spleen as expressed in former editions, and with the conviction that I have assigned one use of the splenic vessels, and afforded an explanation of their tortuous form; but these remarks do not explain the structure of the body of the spleen.

* This has been supposed to be the effect of the impulse of the blood, but nothing can be more false. Let any one examine the artery of a limb when a great tumour is growing; the artery will be found tortuous to supply it. Again, in the aneurismal varix where there is a breach in the artery, and the blood finds a freer return to the heart, the artery will be found enlarged and tortuous in order to supply the lower part of the limb; while there is a quantity of the blood withdrawn from the circulation by the communication with the vein.

That there are cells in the spleen is very generally believed, and that some operation connected with the economy is performed there is also a general belief. Sir Everard Home was of opinion at one time that the spleen drew the fluids from the stomach, and delivered them into the circulation. But finding that infusions of rhubarb got into the circulation from the stomach when the pyloric orifice was tied, and the spleen taken away from the animal, he gave up that opinion. But he has made experiments which lead to the belief that a secretion is poured into the cells of the spleen, but for what purpose these cells or this secretion is still conjecture.

The probability is, and it amounts to no more, that the venous blood of the spleen is useful in the function of the liver. Either it may supply venous blood in proportion to the wants of the liver, or in that venous blood carried to the liver, there may be some peculiar change wrought by the spleen, and fitting it for the secretion of bile.

SECTION IV.

OF THE URINARY ORGANS OF THE KIDNEY.

The kidneys are distinct from those parts which have hitherto engaged us, as they secrete the urine, and form therefore the link betwixt the viscera of the abdomen, and those of the pelvis; for though lying in the abdomen, they are more strictly connected with the parts in the pelvis. The structure of the kidney forms a very interesting subject of inquiry; because it is the field of dispute betwixt the contending parties regarding the structure of the glands and the theory of secretion. It is chiefly from the kidneys that the facts are drawn in illustration of the opinions of Malpighi, Ruysch, and all the others.

Form, seat, and connections.—The kidneys lie on each side of the spine; sunk as it were in the fat of the loins; attached to the muscles of the loins; and in part lying on the lower belly of the diaphragm; which last connection is the cause of the pain felt in respiration during inflammation in the kidney. The kidney lies betwixt the spine of the ilium and the lowest rib. The right kidney is placed somewhat lower than the left, which is owing to the greater size of the liver on that side.

The kidneys are without the abdomen, that is to say, behind the peritoneum; for the kidney lying close upon the muscles

of the loins, the peritoneum is merely stretched over it. This is the reason why calculi in the kidney have wrought themselves out by fistulæ in the loins; and it is the ground of the hazardous proposal of cutting into the kidney to extract calculi.

The adipose membrane surrounds the kidney, and forms a kind of capsule; for it is this which is sometimes in an extraordinary degree loaded with accumulated fat. Upon this capsule the cæcum is attached on the right side, the colon on the left, and betwixt the kidneys and the intestines there is a strict sympathy, which is apparent in the nephritic colic. The proper coat of the kidney is fine, dense, and firm, and closely surrounds its proper structure.

The figure of the kidney is that of an oval bent, or a little incurvated, so as to form a sulcus or general concavity to one side, while the other takes a greater convexity. By the concave surface of the kidney, which is towards the spine and great vessels, the arteries and veins and ureter pass in by the sinus, round which the substance or glandular body of the kidney terminates abruptly.

The abdominal aorta and the vena cava lying close on the spine and near to each other, give off laterally the emulgent arteries and veins. The renal or emulgent artery comes from the side of the aorta betwixt the upper and the lower mesenteric arteries: that of the left kidney has its origin a litle higher than the right: and the aorta being on the left and the cava towards the right side of the spine, the left emulgent artery is shorter than the vein; the artery longer than the vein on the right side. Again, the aorta being more closely attached to the spine, the emulgent vein lies rather above the artery.*

The vessels, and especially the arteries of the kidney, are very irregular in their number and form. Where they enter the body of the gland, they are accompanied with a capsule which continues with them to their final distribution. Sometimes a solitary vessel is seen making its exit by the convex surface of the kidney.

We have had occasion to remark on the nerves of the kidneys and their connection with the coverings of the testicle, and to notice their effect in producing numbness of the thigh and retraction of the scrotum in inflammation of the gland, when stones lodge in the pelvis or ureter.

Upon the subject of the sensibility of the kidney, however, we must be aware that disease, inflammation, suppuration, nay

* The vessels of the kidney vary greatly. C. H. Meuder de urinæ excretione, Sandifort, Thes. vii.—Albinus Acad. Annot. b. vii. c. ii.

even total wasting of the kidney may take place without any indication from pain.

The excretory duct of the kidney is called URETER: it leads from the kidney to the urinary bladder. When we trace it backwards into the kidney it is found to enter the sinus of the kidney. Here it is enlarged into a considerable sac which is called the PELVIS of the kidney. This is a kind of reservoir which, lying in the embrace of the solid and glandular part of the kidney, sends up several elongations like the finger of a glove. These are called *infundibula.* They are indeed like funnels, for they expand to receive the papilla of the kidney from which the urine distils.

It may be observed, however, that the term pelvis is taken from the greater dilatation of the ureter within the gland, which is seen in brutes; and that in man it is not so remarkable, the ureter branching with only a lesser degree of the sacculated form into three or four divisions, and these into the infundibula.*

The coats of the ureter are three in number; a dense outer coat; a middle coat apparently consisting of circular muscular fibres, though this has been denied; and a smooth inner coat, (very improperly called villous,) which secretes a mucus to defend it from the acrimony of the urine. The ureters do not run in a direct course to the bladder of urine; they take a curving direction; are in some places irregularly dilated, as when they pass over the psoas muscle,† dropping deep into the pelvis, and getting betwixt the rectum and bladder, they open obliquely into the latter.‡ The use of the ureter is to conduct the urine which is incessantly secreted§ in the kidney to the urinary bladder, where it can be retained and discharged at a convenient time.

MINUTE STRUCTURE OF THE KIDNEY.

LET us now attend to the structure of the gland. The ancients, says Malpighi, contented themselves with the idea of a sieve, as conveying a knowledge of the manner in which the

* In my Collection specimens may be seen of the pelvis in the human kidney dilated to contain some ounces.

† When the bladder is contracted in consequence of a stone, or when it is dilated by obstructions, as from stricture, the ureters become dilated to the size of small intestines. Specimens may be seen in the Collection.

‡ *Nuck* describes the ureters as being very irregular, and always contracted in three or four places. *Bartholin,* though he observed valves as the duct enters the bladder, and Coschwitz describes valves in their course.

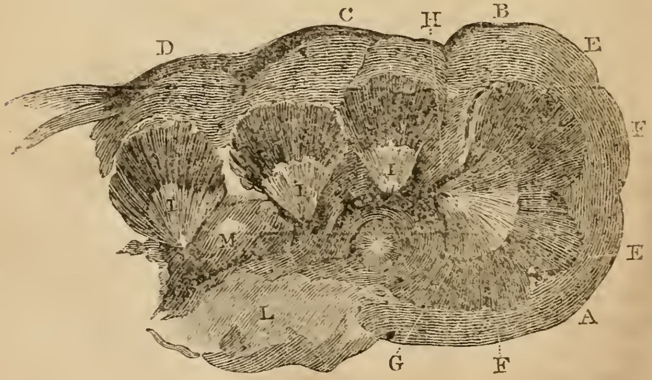
§ When a fistula of the loins communicates with the kidney the urine flows uninterruptedly.

urine was drawn off by the kidney; that the fibres of its parenchymatous matter attracted the serum of the blood; that the fibrous matter was perforated with innumerable foramina; or that the whole was a congeries of canals through which the urine was strained and drawn off. Malpighi set himself to refute these vague opinions by the minute examination of the structure of the kidney; and he seems to have known almost all that we now know. Though we do not acquiesce in his opinions regarding the final and minute structure, he describes accurately every part of the gland.

In the first place, when we examine the outward appearance of the kidney of the fœtus, we observe that it is not, like that of the adult, smooth and uniform, but tuberculated or lobulated; that it consists of distinct parts, or glands united together. Again, when we examine the kidneys of other animals, we find in several instances that the full-grown animal retains this lobulated form. In short, it immediately strikes us, that the kidney is not a uniform mass of glandular matter, but that it most resembles those glands which they call conglomerate, and which consist of several compartments or distinct glands united together.

Accordingly a section of a kidney shows us that this is the fact.

Example of the Lobulated Kidney.



The* section of the kidney shows us these parts. First, we see towards the surface that which is called the cortical or

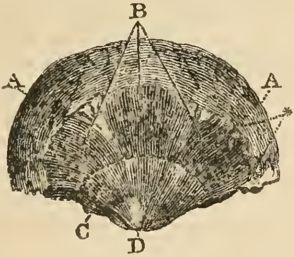
* *Explanation of the annexed plate.*

A B C D. The several divisions of the kidney which give it the lobulated figure.

E E. The cortical part of the kidney, being the outer, and, it is supposed, the secreting part.

glandular part E. Secondly, striæ, converging towards the centre of the kidney, being what is called the tubular part of the kidney.* These tubuli are divided into fasciculi, taking a conical shape; and these converging unite at the apex; two or three of them united form a papilla. The papillæ are generally ten or twelve in number, or even more, in each kidney; their points are received into the extremity of the infundibula; they pour the urine into these tubes, which is collected in the pelvis.

When we examine one of these papillæ in a lobulated kidney, we find that it is the centre of one of these subdivisions. Thus,



A. A. *Cortical Substance.* B. *Tubular part.*
C. *Papilla.* D. *Ducts.*

The papilla C is merely the continuation of the tubuli B; but it is that part which projects from the body of the kidney into the calyx or infundibulum; and although these divisions of the substance of the kidney are enumerated as three distinct parts, the cortical, tubular, and mamillary parts, they are properly only two, the cortical and tubular parts.

Some however have made a new distinction, by asserting that a vascular part is to be observed betwixt the cortical and tubular, or striated parts; but it is not the case; for although, when we make a regular section of the whole gland, the mouths

F. F. The tubular part of the kidney.
G. The papilla, or that part which projects into the calyx or infundibulum of the pelvis.
H. The ducts of Belini in the point or apex of the papilla.
I I I. Other papillæ.
N. B. This represents only one half of the kidney.

* Improperly medullary, sometimes STRIATA. Winslow (*traité du Basventre*) has these distinctions of the substance of the kidney. 1. Corticale. 2. Cannellé, sillonnée, ou tubuleuse. 3. Mammelonnée.

of some larger vessels may be observed betwixt the fasciculi of the urinary tubes, yet they are irregular ramifications tending to the outer cortical part, and not such as separate the tubular and cortical part, nor so regular as to be considered as one of the subdivisions of the kidney.

OF THE CORTICAL PART.

The external and cortical part of the kidney is by all allowed to be the secreting, or, as they rather term it, the secerning part of the organ. It was this part which the older writers considered as in a more particular manner to consist of a peculiar fleshy substance, or parenchymatous matter. It is in this cortical matter that the glandular bodies described by Malpighi are supposed to be seated; they are called corpora globosa. They are to be very distinctly seen in many brutes; for example, in the horse's and cow's kidney; and they are to be seen represented in these plates. But he asserted these bodies to be also observable in the human kidney; to demonstrate which he injected a black liquid mixed with spirit of wine, by which the kidney becoming universally tinged, you may then see, he said, when you have torn off the coats of the kidney, small glands partaking of the colour of the arteries. These are the glands of the cortical part of the kidney, which Malpighi described as hanging upon the branches of the arteries like fruit upon the pendant branches, and round which the arteries and veins ramified and convoluted, like delicate tendrils, so as to give them the dark colour which they have.

Into these bodies he supposed the urine to be secreted, and that from these bodies it was conveyed into the uriniferous ducts or tubular part of the kidney; but he acknowledges that the communication betwixt the ducts and glands is very obscure.

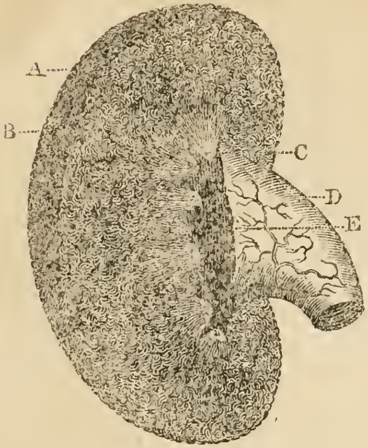
Ruysch and Vieussens held a very opposite opinion regarding the structure of the kidney.* Ruysch, by throwing his injections into the renal arteries, found that he filled the urinary tubes, the ducts of Belini, and the pelvis itself. Hence he conjectured that the tubuli uriniferi or excretory ducts of the kidney were the continued branches of the renal artery, without the intervention of any glandular apparatus.†

* Ruysch and Vieussens long contended for the claim of the discovery of the continuation of the arteries of the kidney into the urinary ducts. Ruysch at first acquiesced in the opinion of Malpighi, as we have said.

† Thes. Anat. ii. p. 31.

Example of Ruysch's doctrine.*

Ruysch's Plate.



Ruysch did not neglect the examination of the little bodies which are to be seen in the cortical substance. He did not however allow they were glands, but confidently asserted that they were merely the convoluted arteries which were formed into these contorted bundles before finally stretching out, and terminating in the straight urinary tubes.†

* Exhibet renis humani dimidiam partem ita dissectam, ut reptatus vasorum, presertim sanguineorum, loculentius quam in preccedenti Thesauro, tab. iv. fig. iii. videre possit; ubi magis inherebam, ut conjunctiones arteriolarum cum ductibus Belini exhiberem, in hac autem figura distinctissime vasorum sanguineorum cursum vermicularem per interiorem renis partem exprimere volui.

A. Facies renis exterior perquam vasa sanguinea reptatum observant vermicularem.

B. Facies renis interior ubi vasa sanguinea non minus cursum vermicularem observant quam in facie exteriore.

C. Papillæ renales.

D. Pelvis renis.

E. Cavitas pelvis in quam papillæ urinam stillando exprimunt.—See Thesaur. Anat. W. p. 27.

† In hoc Thesauro X. quoque inveniuntur objecta renalia ex homine desumpta, in quibus non solum luculenter apparet quid judicandum sit de prætensis glandulis renalibus, verum etiam quid investigatoribus renum imposuerit, se in renibus indagandis sæpissime occurrunt corpuscula rotunda glandulas mentientia quæ revera nil sunt nisi arteriolarum ultimæ extremitates contortæ; cum autem exactissime repleantur arteriæ renales dissolventur vel expanduntur, quemadmodum fili glomer, ita ut nil minus sint, sicuti dixi, quam partes per se subsistentes & peculiari membranula obductæ sine quo immerito dicuntur glandulæ. Interim considerandum ejusmodi contorsiones vasorum sang.

When after minute injection of the kidney we make a section of its whole substance, we see vessels emerging from the more confused intricate vascularity of the cortical part, and running inward in striæ towards the papillæ; what we see there are, in my conception, chiefly veins. And this I conclude, both from the result of injections, and from knowing that the veins are in general numerous surrounding the excretory ducts; besides they retain the blood in them like the veins. These vessels running in straight lines and converging towards the papillæ are not the tubuli uriniferi, but the blood-vessels accompanying them, the tubes themselves being transparent.

Yet I imagine it was by these vessels that Ruysch was deceived; for tracing them from the extreme arteries, and seeing them suddenly altered in their form and direction, and running towards the papillæ, he imagined them to be the excretory ducts continued from the extreme branches of the arteries.

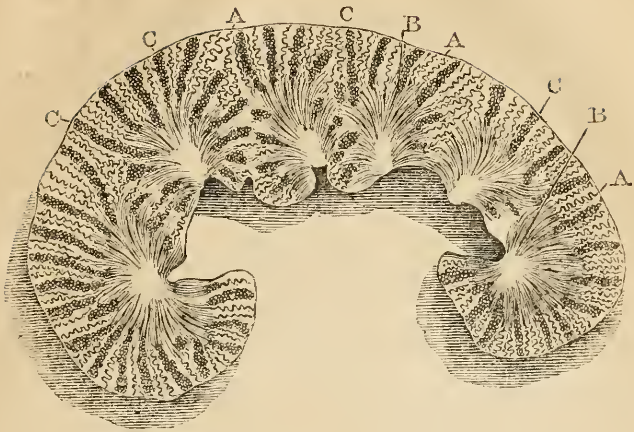
Winslow supposes the corpuscules, which are seen in the cortical part of the kidney, to be the extremities of the cut tubuli filled either with blood or with a coloured injection. But this they evidently are not; for by making the substance around them transparent, they are seen within the surface, and they are little grains, not the extremity of tubes, nor extended in lines.

Boerhaave, although he saw in the preparations of Ruysch the injection passed into the uriniferous tubes, yet in the main favoured the opinions of Malpighi; and having sometimes observed these tubes filled with injection, while at intervals they were transparent or pale, and contained only a watery fluid, he ventured to conclude that there was a double operation going forward in the kidney; that the pale watery urine was quickly drawn off, by the continuous tubes; but that the urine of the other quality and higher colour was separated by a more perfect and slower secretion through the glandular bodies.

In the history of opinions, to Boerhaave succeeds Bertin, who writes a long and laboured paper in the memoirs of the Academy of Sciences for 1744; upon the whole, he may be considered as endeavouring to prove by dissection what was rather an hypothesis with Boerhaave. Bertin describes glands in the substance of the kidney; but these he is careful to distinguish from the corpuscules of Malpighi, which he also conceives to be the extremities of vessels merely.

nusquam in cæteris visceribus reperiri. In the epist. to Boerhaave, p. 77, we find Ruysch speaking much more modestly: "In rene humano rotunda corpuscula esse, fateor, sed sunt tam exilia, ut nihil possim definire de illis. Adeoque non licet magisdicere quod sint glandulæ, quam aliud quid."

M. Burtin's Plate.



From this plate we shall easily understand Bertin's description. He observes, in the first place, that there are to be seen serpentine vessels, such as Ruysch described: for example, at A A A,* which arising at the circumference of the cortical substance, are reflected inward in a tortuous form, and which, at last, approaching the tubular part, terminate in straight tubes, or are continued into the tubuli uriniferi (for example at B B.)

But betwixt the meshes of vessels which are described, and which are seen here to terminate in the tubuli, there are beds of glands C C C, which acervulæ of small glandular bodies are as it were laid in the tract from the circumference towards the centre, and appear to terminate or to be connected with the tubuli uriniferi as the arteries are.

M. Ferrein has opposed all these opinions in a paper of the Academy of Sciences for 1749. He asserts that the body of the kidney is neither composed of glands nor a congeries of blood vessels; that it is a peculiar substance, which when examined is found to consist of transparent vessels. These, he says, are wonderfully convoluted in the cortical part of the kidney, so as to resemble glands, and stretch in parallel lines towards the papillæ, where they form what is called the tubuli uriniferi. Amongst these transparent tubes the blood-vessels ramify to great minuteness, and accompany them where they are

* Mesches de M. Winslow ou vaisseaux spongieuses de Vieussens ou tuyaux erpentans de Ruysch.

reflected directly inward to form the tubuli. Much ridicule, he observes, has been thrown upon the term parenchyma of the ancients; but notwithstanding he affirms, that there is in all glands a substance dissimilar from the blood-vessels, a gelatinous-like matter, which consists of or contains these pellucid tubuli.

Tubular part.—The term here used is universally received; and all seem agreed that the striæ converging to the centre of the kidney, and taking a pyramidal shape, are the excretory ducts. We have seen that they were supposed by some anatomists to be formed by the continuation of the extreme branches of the arteries; but this opinion we shall venture to say arose from the appearance of the blood-vessels injected, which lie parallel and close to them. They are evidently transparent tubes, and probably the fibrous appearance of the whole pyramidal body formed by them is owing to the accompanying blood-vessels. These lesser ducts, as they approach the papillæ, terminate in larger ducts, which finally open into the ducts of Belini at the point of the papillæ. The papillæ we have seen to be that part of the pyramidal body which projects into the calyces or infundibula, and from their point little drops may be perceived to form when they are compressed. This fluid comes from the ducts of Belini.

I have detailed the several opinions regarding the structure of the kidney; and neither do I wish here to vamp up an opinion from the aggregate of these contradictory reports, nor have I been able to draw a decided conclusion from my own experience. In truth, the observation from one dissection I have hitherto found so completely contradicted by other experiments, that I must conclude there yet remains much to be done in investigating the minute structure of the glandular viscera.*

OFFICE OF THE KIDNEYS.

The kidneys secrete the urine: but this drawing off of the fluid from the system is not the sole object of the secretion; the water conveys away certain matters in solution. As the urine contains more saline matter than any other secretion, we are led to suppose, that the kidney is of use to rid the system of these saline substances.

These principally consist of the muriatic salts, as the muriate of potash and soda, the phosphoric salts, as phosphate of soda

* Of the kidney much in Morgagni Advers. Anatom. iii

of lime, and ammonia; the phosphoric and lithic acids, with animal extractive matter, and a gelatinous or albuminous matter. In short, chemists have declared, that eleven substances are constantly present in the urine, and occasionally others, the product of morbid action; so that from the kidneys, much, both of the solid and fluid composition of the frame, must be sent off in that circle of action, deposition and absorption, by which both the structure of the frame and the qualities of the living body are preserved.

OF THE CAPSULÆ RENALES.*

The renal capsules are glandular bodies of a reddish yellow colour, one attached to each kidney. The gland is seated like a cap on the upper end of the kidney. It is of a form like an irregular crescent, and suited to the shape of that part of the kidney to which it is attached; at the same time that it has three acute edges, being something of a triangular form.—The upper edge has been called crista, while the lower edges have the name of lobes. It is in the fœtus and in childhood that the renal capsule is large and perfect; in the adult it has shrunk, and no longer bears the same relative size to the kidney. In the fœtus the renal capsule is as large as the kidney, and the capsules of each side are continued into each other, being stretched across the aorta and vena cava.†

The vessels sent to this body are somewhat irregular; they come from the renal or emulgent arteries and veins, from the cœliac artery or phrenic, or from the trunk of the aorta, and even from the lumbar arteries.

By separating the lobes of this body we find something like a cavity, which has been roundly asserted by some to be a regular ventricle; by others altogether denied. Finding a cavity, they supposed they must discover the excretory duct. Some conceive that it must be connected with the pelvis of the kidney; some with the thoracic duct; some with the testicle; but every thing relating to the use of this body has hitherto eluded

* *Glandulæ atrabilariæ, renes succenturiatæ. Glandulæ renales, &c.*

† For various authorities on the size and appearance of this body, see Morgagni Epist. Anatom. xx.

research, and all is doubt and uncertain speculation.* For my own part I conceive that this body is useful in the fœtus, by deriving the blood from the kidney, that gland not then having undertaken its proper office of secreting the urine.

* *Morgagni* Adversar. An. iii. A. xxxii. 329. *Valsalva* is reduced to the necessity of quoting Scripture, and Morgagni is as much at a loss, Epist. Anat. xx. being obliged to join in the words of Eustachius: "iis relinquamus, qui anatomen acuratus exercent, inquirendum." Morgagni, loc. cit.

THE

ANATOMY

OF THE

MALE PARTS OF GENERATION.

AS there is no very accurate division betwixt the viscera of the abdomen and those of the pelvis; as the uterus and bladder, being viscera of the pelvis, rise into the belly when distended, and are in every respect like the abdominal viscera, many have objected to a division of the viscera of the abdomen and pelvis: nevertheless, there appears to be good reason for this division of the subject. The function of the parts is different; the manner of their connection is different, and their diseases have widely different effects.

We have seen that the pelvis consists of the sacrum, or coccygis, and ossa innominata, and that anatomists have distinguished the true and the false pelvis. The false pelvis is formed of the extended wings of the ossa ilii, and supports the viscera of the abdomen. The true pelvis consists of that cavity which is beneath the promontory of the sacrum and the linea innominata; it contains, in man, the rectum, the urinary bladder, the prostate gland, the vesiculæ seminales, and part of the urethra. In woman it contains the rectum, vagina, uterus, Fallopian tubes, ligaments of the uterus and ovaria.

The manner in which the parts of the male pelvis are connected, and the anatomy of the urinary bladder, prostate gland, and urethra, will form the subject of the first section;

while the anatomy of the parts connected with those of the pelvis in function, but seated without, will form the subject of the second.

CHAP. III.

OF THE PARTS WITHIN THE PELVIS.

We have seen that the abdominal viscera are involved in a common membrane; that this membrane is uniformly smooth; and that it has a secretion on its surface which bedews the whole, and allows the parts an easy shifting motion on each other. The parts in the pelvis must also have motion, but they are at the same time more intimately connected; a loose cellular membrane is the medium of adhesion here: the parts are imbedded in cellular membrane which is interwoven with muscular fibres towards the lower opening of the pelvis, and further braced by the levator ani and muscles of the perineum. This gives to the whole due support; enabling them to resist the compression and action of the abdominal muscles, which they must receive in common with the higher viscera of the belly.

By turning to the first plan in this volume, we find, that the division of the parts in the pelvis and abdomen is not well defined; but we see that the peritoneum is reflected from the pubes over the urinary bladder, and mounts again upon the rectum. The line of division, therefore, is the peritoneum; while we understand how the bladder which belongs to the pelvis, being distended, carries the peritoneum before it, and rises into the abdomen.

SECTION I.

OF THE BLADDER OF URINE.

The bladder of urine must be classed with membranous or hollow viscera. It is a bag or receptacle into which the urine

slowly distils through the ureters, that it may be expelled at convenient seasons. It is nearly of a regular oval, when moderately distended, the ends being obtuse; but from its connections, and the pressure of surrounding parts, this regular extension is not allowed in the living body. When seen moderately distended in situ, it rises somewhat pyramidal upwards, it is flat upon the os pubis on the forepart, and towards the back and lower part a portion may be seen somewhat sacculated, and below the level of the commencement of the urethra.

We describe the body, fundus, neck, and lateral parts. The fundus is the upper part; the neck is where the urethra commences, and where the prostate gland is attached; the lateral part is, where being distended it stretches at its lower part to the sides of the pelvis.

On the fundus there is a ligamentous process, continued in a direction towards the umbilicus; this is the uracus. I would not mention it here, being a tube peculiar to the fœtus of quadrupeds, was it not to add that it is sometimes even in the adult human subject open, so that the urine passes out from the umbilicus.*

When the bladder is empty, or contains only a moderate quantity of urine, it takes a triangular figure in the dead body, the base of which rests on the rectum, and the apex is attached to the back of the os pubis; and when in dissection you look down into the pelvis, you find the back part of the bladder flat, and as it were stretched obliquely up upon the os pubis.

Structure of the bladder.—Like the other hollow viscera, the bladder consists of several coats.

The peritoneal coat of the bladder does not surround the bladder, but only covers the fundus and back part. It is like in every respect to the peritoneal coat of the abdominal viscera; smooth without; and adhering to the inner coat by cellular membrane; which cellular membrane is, however, of a looser texture, and in greater quantity than under the peritoneal coat of the abdominal viscera. This peritoneal coat is no doubt of much service, as a division in obstructing the course of inflammation arising from the diseases in the lower part of the pelvis, or from operations performed on the bladder, rectum, or perineum; were it not for the loose peritoneum spreading over the cellular texture of the pelvis, we could neither be so bold nor so successful in our operations here. That portion of the peritoneum which covers the back part of the

* *Fernelius de part. morb. & symptom.* gives an example of a man who, having an obstruction at the neck of the bladder, passed his urine by the umbilicus. Wepfer gives a similar case of a man with calculus. These are quoted by *Albinus Annot. Acad.* and also the Philos. Transactions, n. 323. See also Sandifort Thes. Vol. iii. p. 234—246.

bladder, forms a particular transverse fold when the bladder is contracted. This fold surrounds the posterior half of the bladder, and its two extremities are stretched towards the side of the pelvis, so as to form a kind of lateral ligament.*

Though in the contracted or moderately distended state of the bladder, the peritoneum stretches from the back of the os pubis to the bladder, the distention of the bladder, in an immoderate degree, raises the peritoneum off from the pubes, so that the bladder can be struck with a trochar, or lithotomy performed above the pubes, by an incision directly into the bladder, without piercing the outer or peritoneal coat.

Towards the lower part, the bladder, as we have seen, is invested only by cellular membrane, which takes the place of the peritoneal coat of the fundus. This tissue is very loose, and permits the distention and contraction of the bladder, which looseness of texture is a matter of regret, when blood or urine is forced into this tissue.

MUSCULAR COAT.—The muscular coat of the bladder is very strong. Three strata of fibres are described by authors. They are so strong as to have been classed with the distinct muscles, and the whole coat has been called DETRUSOR URINÆ. Towards the lower part of the bladder the fibres are particularly strong, and formed into fasciculi, and are like a net of muscles inclosing the bladder.† These fasciculi acquire greater thickness and strength when the bladder is excited by opposition, as from stricture in the urethra.‡

Towards the fore and lower part of the bladder, the muscular fibres congregate into a sort of tendon, which goes off to the back of the os pubis, which we count to be the insertion of the tendon of the bladder, and certainly this hold, which the bladder has upon the os pubis, causes it, in its contraction, to be drawn to the back of the pubes.

We have an idea of the wonderful degree of contraction in the bladder, and indeed the extent of motion in the muscular fibre in general, when we consider that the bladder extends so as to contain two pounds of urine, and contracts so as to force out the last drop from its cavity. When, however, the fibres are stretched too far, they lose the power of contraction, and often the young surgeon is deceived by what he conceives to be an incontinence of urine, while it is really an obstruction.

The true sphincter of the neck of the bladder has hitherto escaped notice: it has been looked for on the outside of the prostate gland, and then the compressor prostatæ, the levator

* See description of the folds of the peritoneum.

† Morgagni Adversar. Anat. iii. Animad. xxxix.

‡ Some very remarkable examples of this may be seen in my Collection.

urethræ, and the levator ani, have been considered as sphincters, and so indeed they are, inasmuch as during their action the urine cannot be expelled along the urethra; but the true and appropriate sphincter of the bladder lies under the base of the prostate gland, and immediately surrounding the beginning of the urethra.

THIRD COAT.—This third coat of the bladder anatomists have called the nervous and cellular coat; it consists of very extensile white lamellæ of cellular membrane. It gives distribution to a few vessels, and connects the muscular fibres and inner coat.

The INTERNAL COAT of the bladder is very smooth on its general surface, and is bedewed with a sheathing mucus. When the bladder is distended, no inequalities are to be observed; but when contracted, it falls into folds and rugæ. From an acrid state of the urine; from stranguary, from calculus, the mucous discharge is increased, even so as to form a great proportion of the fluid evacuated from the bladder. No visible source of this mucus is to be observed on the inner surface of this membrane;* so that probably it is a general discharge from the surface. Indeed, it appears, that no follicules or cryptæ, discharging at particular points of the surface, could have the effect of bedewing and defending the whole surface from the acrimony of the urine.†

The URETERS, which convey the urine from the kidneys to the bladder of urine, open very obliquely into the bladder, towards the back and lowest part of it. The consequence of their oblique perforation of the coats is, that, the greater the tendency of the urine to pass retrograde into them from the bladder, (there being a proportioned distention of the coats of the bladder,) the more their mouths are compressed. Thus, in the dead body, there is no degree of distention which causes the water to pass by the ureters. The contraction, or rather the resistance to distention, of the ureters and pelvis of the kidneys, seems much greater than the powers of the bladder are able to oppose; for in obstructions of urine in the urethra there is still an incessant accumulation in the bladder, even when the bladder has increased to such a size as to be compressed by the action of the abdominal muscles. The cause of this yielding of the bladder to the secretion of the kidney is, that it has little permanent contraction, though occasionally its action is very great.

* Winslow, however, describes the glands, and Heister and Haller describe follicules, near the neck of the bladder, and round the insertion of the ureters.

† When the mucous secretion is diminished by a disease of the inner membrane of the bladder, the calculous concretion more readily forms on the surface.

*Corpora carnea.**—Where the ureters terminate, there are two fleshy bodies stretching forward, which run together near the opening of the urethra; and at their meeting there is a prominence of the inner membrane of the bladder. From this prominence a line is continued forward, which terminates in the *caput gallinaceum*. These fleshy cords are muscles of very particular use, they restrain the termination of the ureters, and preserve the obliquity of the passage of these tubes through the coats of the bladder when it is contracted; without this provision the urine would be sent retrograde into the ureters, instead of forward into the urethra.†

The URACHUS does not belong to the human bladder. It is a tube which, in the fœtus of quadrupeds, communicates betwixt the bladder of urine and the membrane called alantoes. But in the human fœtus there is no such communication; both in the fœtus, and somewhat less distinctly in the adult, there is a ligament like the remains of the duct which runs up between the peritoneum and linea alba of the abdomen towards the umbilicus.

SECTION II.

OF THE PROSTATE GLAND.

On the neck of the bladder, and surrounding an inch of the beginning of the urethra, there is a gland nearly of the size and figure of a chesnut. This body is called the prostate gland. In all the extent of anatomy, there is not a more important subject for the attention of the surgeon than this of the size, relation and connection, and diseases of the prostate gland.

The shape of this body is round, at the base which is towards the bladder, pyramidal forward. It has a lateral division, forming it into two lobes; and the older anatomists speak of it as double. Mr. Hunter and Sir Everard Home have excited our attention to the posterior or third lobe of this gland, and have drawn the most important practical remarks from the observation of this part of the anatomy; while the prostate gland surrounds the beginning of the urethra, it rests on the rectum, and it is tied by a fascia or ligament to the back

* *Corpora Carnea Morgagni.* Vide Adversar Anatom. i. 9. A. iii. 421. Mammeleon allongé *Splanchnologie, par R. J. C. de Garengeot.*

† See a paper by me on this subject in the 3d vol. of the Medico-Chirurg. Trans.

part of the os pubis. The urethra passes through it; not in the middle, but towards its upper surface; so that the gland is more prominent downward, and is distinctly felt by the point of the finger *in ano*. When the catheter is introduced, and the surgeon examines the state of parts by the rectum, he will first distinguish the curve of the staff, covered with the bulb of the urethra: behind this the catheter will feel more bare of parts, but still covered with a greater thickness of parts than one should expect from the description of the membranous part of the urethra. And behind this, again, he will feel the prominence of the prostate gland, not round, distinct, and accurately defined, but gradually lost both before and behind, among the surrounding cellular membrane and muscular fibres which involve it.

The texture of the gland is a compact spongy substance, and when cut has considerable resemblance to a scirrhous gland. From each lobe there are small follicules opening into the urethra, and from these the ducts may be injected.*

It has been said that there is really no division of this gland into lobes; but perhaps the best authority on this question is the morbid appearance. Now it happens sometimes that only one side of the gland is enlarged, which is a proof that there is some division betwixt the lobes. This unequal swelling of the gland distorts the urethra, and gives it a direction very difficult to be followed by the catheter. In general, when equally swelled, the greater part of the gland, being beneath the urethra, raises it up so that the point of the catheter must be raised over the enlarged gland before we can pass it into the bladder.

On the lower part of the gland, and betwixt the bladder and the vesiculæ seminales, the third portion of the gland is situated, of which Morgagni gives this account. But if any addition is to be given, says he, to the description of the prostate gland, it is that roundish and smooth body like a gland which often our very diligent dissector has shown in the public dissections. It lies prominent betwixt the bladder and seminal capsules where they are united. Upon our most accurate examination, we find this to be nothing more than a part of the prostate itself.† After this I can see no objection to calling this part of the prostate gland Lobus Morgagni. Morgagni likewise observes that it is not always to be found.

The prostate gland secretes a ropy mucus. It is probable

* As first done by Monro.

† Vide *Morgagni Adversaria Anatomica, Animadversio* xv. *Prostatæ propago.*

that this mucus serves to sheath the passages and preserve them from the acrid urine. It certainly unites also to the seminal fluid, and is discharged with it.

The diseases of this gland form a subject too important and extended to be even hinted at here.*

Anterior to the prostate gland, and also close to the urethra, are seated the GLANDS OF COWPER. This gland is also for the purpose of discharging mucus into the urinary passage. It is seated in that angle formed by the abrupt termination of the bulb of the spongy body of the urethra, and consequently close to the membranous part of the canal. It has a long duct, which, running forward an inch in length, terminates in the surface of the urethra. To comprehend the anatomy of the male urethra we must first notice the penis.

CHAP. II.

Of the parts connected with the Viscera of the Pelvis, but seated without it.—Of the Penis and Urethra.—Of the Testes.

SECTION I.

OF THE PENIS AND URETHRA.

STRUCTURE OF THE PENIS.

THE penis consists of a spongy substance, admitting venous blood, and supported by a very firm elastic covering, which restrains the over distention, and gives the forms. There are properly three spongy bodies. Two of these bodies are called the CORPORA CAVERNOSA PENIS, and form the body of the penis; the other is the CORPUS SPONGIOSUM URETHRÆ, a vesicular and spongy substance, which surrounds the whole length of

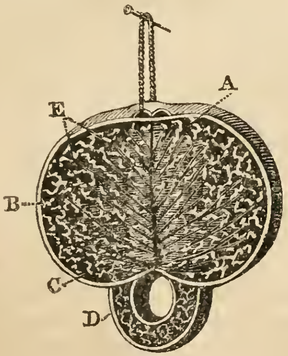
* For much of the anatomy and the morbid conditions of these parts, see SPECIMENS of MORBID PARTS, *taken from the Collection of Windmill-street. Folio.* Longman and Co.

the urethra, and expands into the bulb of the urethra in the peritoneum, and into the glans on the point of the penis.

Corpora cavernosa.—The body of the penis consists of two tubes formed of a very strong sheath. This sheath has a great degree of elasticity, but at its utmost extension powerfully resists the farther distention with blood. These tubes are united in the greater part of the length of the penis, or rather they are parted by an imperfect partition. Within them is a curious tissue which forms a cellular texture ; into this texture the arteries pour their blood so as to occasion erection. The posterior extremities of these cavernous tubes are called crura penis: they separate in the perineum, and each of them takes hold on the ramus of the os pubis. Foreward, these cavernous bodies or tubes terminate in rounded points under the glans penis.

This internal tissue consists of cells connected with each other, and having a free communication through the whole extent of the penis. They are interposed betwixt the extremities of the arteries and veins, or probably while the arteries have communication, and open into the extremities of the veins, in the common way: they have such connexions with the cellular structure, that in the accelerated or excited action they pour their blood into the cells; yet in such a manner, that the blood circulates in the penis during erection as at other times, and the blood in the cavernous body is not stagnant.

Section of the penis, as inflated.



A, Corpus cavernosum Penis. B, Septum. C, Urethra. D, Corpus spongiosum Minus, or spongiosum Urethræ.

Corpus spongiosum urethræ.—Attached to the cavernous body of the penis there is a spongy body similar in structure; through this cellular or cavernous texture the canal for the urine, called the urethra, takes its course, which gives rise to the name spongy body of the urethra, or *corpus spongiosum urethræ.*

The spongy body extends the whole length of the penis, and where it extends backwards into the perineum, betwixt the crura of the penis, it is enlarged into a round head, which is called the *bulbous part;*—it is upon this, and on about an inch and a half of the lower part of the spongy body, that the ejaculator seminis or accelerator urinæ acts; and, as within this enlargement of the spongy body which surrounds the urethræ there is also a dilatation of the tube of the urethra itself, the use of the muscle is evident. It contracts upon this sinus of the urethra when distended with the discharge of the vesiculæ, the prostate gland, and testicle.

Foreward at the extremity of the penis the spongy body is enlarged into the glans: thus forming the bulbous head of the penis which crowns the conical extremities of the cavernous body.

The spongy substance which we have described, admitting the blood freely into its cells, suffers erection at the same time with the body of the penis; and as the blood of the glans has free connection with the blood of the bulb seated in the urethra, we may perceive that the action of the ejaculator seminis upon the back part of the spongy body must affect the whole extent of that body and the glans also. The excitement of the glans gives the action to the accelerator or ejaculator muscle; the action of this muscle compresses the bulb, and in consequence the whole spongy body to the extremity of the glans is made turgid, and compresses the diameter of the urethra, adapting it to the emission of semen. Sir Everard Home, I observe, supposes "that an action takes place in the membrane of the urethra during copulation, to reduce the size of the canal, and fit it for throwing out the semen with the necessary velocity:" I imagine, the action of the accelerator, and the state of distention of the spongy body, will have this effect.

The obtuse glans spread upon the extremities of the cavernous bodies of the penis, has no communication with them. We observe a posterior circular margin on the glans; this is the *corona glandis*, and behind this there is a depression called the cervix. About the corona and cervix there are many little glandular bodies.*

* Glandulæ odoriferæ of Tyson. See Morgagni Adversar. iv. Animad. xii. et sequent *de tuberculis Coronæ penis.*

The PREPUTIUM is a loose prolongation of the integuments of the penis, which hangs over and defends the delicate and sensible surface of the glans. Its inner surface is continued from the common integuments; this is again reflected over the glans. Upon the lower side and just behind the opening of the urethra the preputium is tied in a particular manner to the surface of the glans. This connection limits the motion of the preputium, and is called FRÆNUM PREPUTII.

The whole integuments of the penis are of the same cellular structure with those of the rest of the body; they are particularly loose and distensible, and unincumbered with fat. We may see them in emphysema and in œdema monstrously distended.

OF THE URETHRA.

The urethra is all that length of the canal from the neck of the bladder to the extremity of the penis. It is formed of the continuation of the inner and third coat of the bladder, which last forms a reticular membrane, uniting the inner membrane to the spongy body. It is, however, supported through all its length, near the bladder, by passing through the prostate gland and sphincter fibres; further forward than this, where it passes from the prostate to the beginning of the spongy body of the urethra, it is invested and supported by firm ligamentous membranes and muscles; and in all the length of the penis it is included in the spongy body, which extends from the bulb to the glans. It cannot be described as a cylindrical canal, for it is closed unless distended with urine, and admits of very unequal distention. It begins large at the neck of the bladder; where, immersed in the prostate gland, it forms a little sinus; it is contracted again, in a remarkable degree, behind the bulb; it dilates in the SINUS OF THE URETHRA within the bulbous enlargement of the spongy body; it is gradually diminished forward; and it may be considered as cylindrical or equal in its diameter from this part forward to the point of the glans, where it is much contracted.*

The canal of the urethra is bedewed with mucus. The sources of this mucus are here particularly apparent; for, besides the general surface and the glans which I have described, there are large lacunæ observable; into which mucus is secreted, and from which, as from receptacles, it is pressed

* Haller Com. lib. xxvii. sect. I. § xxx. Mr. Home's Strictures, Observ. de partibus genitalibus sexuspotioris Sandif. Thes. viii. p. 71.

out as the urine flows.* The inner membrane of the urethra is very delicate, and when torn by the catheter, or by violent chordee, or opened by the caustic, bleeds profusely.

The internal membranes of the bladder and urethra are particularly sensible; drawing after them, when excited, not only the action of all the muscles in the lower part of the pelvis, but having sympathies in a particular manner with the testicle, stomach, and bowels, and with the whole system. The more curious and important effect of the injury of the urethra is the paroxysm of fever which it induces. Observing the regular occurrence of an intermitting fever in cases of fistula in the perineum, we should imagine it to be the effect of the extravasation of the urine in the cellular membrane, and the effect of general irritation; until it is observed that the simple stricture produces that effect, and that a touch of the caustic brings on a violent paroxysm.

When the reticular membrane is inflamed, of course it loses its elasticity and gives pain in the erection. Sometimes the inflammation, being continued to the spongy body surrounding the urethra, makes it unequal in its capacity of distention to the cavernous bodies of the penis, and sometimes their cells are united by adhesion in the worst cases of the chordee.

I cannot imagine with some, that the urethra is muscular; *first*, because I see no end it could serve in the economy; *secondly*, because there is no proof in support of the opinion; *thirdly*, because it is surrounded with strong fibres and a spongy body, which conjointly seem calculated for every purpose of the economy, and likely to account for every symptom which might be mistaken for spasmodic action in the canal itself. The idea of muscularity is derived from the symptoms of stricture and the irritability of the canal.†

The urethra is very elastic; not only allowing a very large bougie to be passed, and closing upon a thread, but it still more remarkably admits of elongation than of distention in the

* These are the *Canaliculi Morgagni*, Advers. Anat.—De glandulis urethræ vide Morgagni Adversar. iv. An. vii. et sequent. There is much controversy and much confusion regarding the gland of the urethra, viz. *Prostatæ minores; glandulæ Cowperianæ; glandulæ Littreanæ*, &c. The reason of which I believe to be, that the *lacunæ* do not appear glandular unless when they have suffered by inflammation; there is no round smooth body attaches to them, unless their secretions have been increased and the cellular membrane and vessel are condensed around the lacunæ.

† Morgagni describes the membrane of the urethra as double, having vessels betwixt its laminæ. These are the veins described by Dr. Barclay. Observ. Anat. p. i. tab. iv. J. C. Brims, Sand. Thes. viii. describes two laminæ, one of which he considers to be the continuation of the muscular coat of the bladder.

width of the canal. It is surrounded, as we have seen, with a spongy body and the cellular coat which is betwixt the delicate lining membrane of the urethra, and the spongy body partakes of the structure of both, and is very elastic. But when an inflammation attacks the canal, this cellular membrane is its principal seat. The point affected loses its elasticity; no longer stretches with the penis and urethra, but consolidates, or forms a strong membranous filament. To suppose this stricture to have been formed by the muscular contraction in the diameter of the canal, would be to allow the partial action of one or two fibres; (for the stricture is very that which would be produced by the tying of a packthread round the canal, being a narrow circular ridge;) which is very unlikely. Sometimes, however, the stricture is only on one side of the canal, which, allowing it to be formed by inflammation, is very likely to happen: but in consequence of the muscular action, cannot easily be supposed to take place, since the drawing of the muscular fibres would equally affect the whole circle.

As to the effect of heat and cold on an obstruction, it may be explained simply, without the supposition of muscular contraction; for as we know that the spongy bodies, and of course the whole canal, relax and elongate in warmth, as they are shrunk up and contracted in cold, like the skin of the body in general, without implying muscular contraction: so we see how this state would affect a stricture;—that, when the penis and the urethra were shrunk, the effect of the stricture would be increased, and the patient could pass his urine only when the parts were relaxed, by sitting in a warm room, or by the use of the bath.

But when surgeons speak of spasms of the urethra, they seem to forget the action of the surrounding muscles. Thus acrid and stimulating urine, or an irritable state of the urethra, will be followed by a small stream of urine: or perhaps a temporary obstruction is the consequence: but why should we suppose that the membrane of the urethra, which has no appearance of muscularity, causes this effect, when it is probably produced by the sphincter muscles, the fibres which surround the membranous part of the urethra, the levator ani, and, above all, by the accelerator urinæ, a muscular sheath of fibres surrounding three or four inches of the canal. Round the sinus of the urethra and the bulb which covers it, is the accelerator urinæ, more properly the ejaculator seminis. In short, here are a whole class of muscles which sympathize with the state of the urethra; and these muscles, disordered

in their action when the canal is inflamed, give occasion to those contractions which are attributed to the membrane of the urethra itself.

SECTION II.

OF THE TESTES.

THE TESTICLE might be considered as more naturally connected with the abdominal viscera, than with those of the pelvis, as its original seat is on the loins amongst the abdominal viscera, and as it receives its coats from the peritoneum, its vessels from the abdominal vessels, and its nerves from the plexus belonging to the vital parts.

The testicles are two glandular bodies which secrete the semen: they are seated in the scrotum, and are covered and protected by several coats; they receive their vessels from the aorta and cava, or the emulgent vessels: their excretory ducts run up into the belly, and terminate in the urethra near the neck of the bladder.

The SCROTUM, in which the testicles are lodged, is a continuation of the common integuments; its cellular membrane is particularly lax and free from fat, and the water of anasarca is extremely apt to fall down into it, so as sometimes to distend the scrotum to a transparent bag of enormous size; and not unfrequently the cellular texture here has been blown up to counterfeit rupture and other diseases.

OF THE DARTOS.—The cellular substance of the scrotum is peculiar in its appearance, being red and fibrous. It has been considered as a muscle, and called DARTOS;* although this is denied by many. Its action is to support and brace the scrotum; and in bad health,† and in old age, it is so much relaxed as to allow the testicles to hang upon the cords. But besides the simple corrugation and relaxation, the scrotum has a motion like the vermicular motion of the intestines, obliquely and irregularly from side to side. Its contraction has a relation to the healthy secretion of the gland within, and when for some obstinate disease of the body of the testicle blisters are applied to the scrotum, we may see this muscle in great activity rolling round the testicles. The straight fibres of the

* Δαρτος Veterum.

† Nurses attend to the state of the scrotum in children.

cremaster muscle could not, I imagine, perform this revolving motion, and therefore I conclude that the dartos is a muscle on a testimony better than is to be had from dissection.

There may be traced from the web of cellular membrane which covers the abdominal muscle, a kind of imperfect expansion descending upon the testicles. This becomes very strong when hernia has taken place at the ring.*

SEPTUM. Upon the surface of the scrotum, directly in the middle, there is a line passing from the lower part of the penis to the anus; the RAPHA. This line marks a division in the scrotum, a partition, or septum, which divides the scrotum into two distinct cellular beds for the testicles.

COATS OF THE TESTICLE. Over the proper coats of the testicle the *cremaster* muscle is expanded. The origin of this muscle (as we have seen in vol. i.) is from the internal oblique muscle of the abdomen. It passes through the hole of the external oblique muscle called the *ring* and descends over the vessels to the testicle, constituting a part of the cord and finally spreading its fibres over the *tunica vaginalis testis*. Its use is to suspend and draw up the body of the testicle.

Under the fibres of the muscle we may discover a process of cellular membrane which comes down from the cellular membrane behind the peritoneum, and has been usually called a process of the peritoneum, even before the coats of the testicle were discovered to be originally formed by that membrane.

Besides the involving scrotum, each testicle has distinct coats. The TUNICA VAGINALIS, according to our best authors, covers the testicle loosely; that is, without adhering to its general surface: but the albuginea is in close union with it, and is the immediate coat of the testicle. The inner surface of the vaginal coat is perfectly smooth, and an exudation is poured out from it, as from the peritoneum within the belly. The outer surface of the tunica albuginea is also smooth and firm, and white, whence its name; but on its inner surface, like the peritoneum, which covers the intestine, and adheres to the muscular coat, it adheres to the proper substance of the testicle. These investing coats are in some respects dissimilar, yet in general much alike, one being continued into the other, and both prolongations of the peritoneum. The outer membrane, the tunica vaginalis, is a protection to the testicle; gliding easily on the inner coat, and aided by the mobility of the cellular

* *Mauchart* de hern. p. 14. tab. 2. *Garengeot Haller.* Monro.—I have during operation divided this into three lamina.

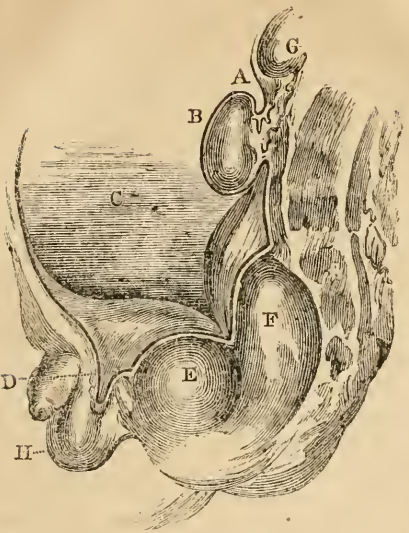
membrane of the dartos, it preserves the testicles from bruises and strokes to which it would be exposed if it were more firmly attached. The inner tunic or albuginea, gives strength and firmness to the substance of the testicle. Betwixt these coats is the fluid collected, which forms the hydrocele. They also contain the congenital hernia; but the common hernia is without both coats of the testicle. To understand the anatomy of this part thoroughly we must attend to the descent of the testicle, and to the manner in which these coats are formed.

OF THE DESCENT OF THE TESTICLE,*

In the fœtus, some months before birth, the testicles are lodged in the belly, and are in every respect like the abdominal viscera. They are seated on the forepart of the psoæ muscles by the side of the rectum. They are covered and invested by the peritoneum; for, as we have explained how the solid viscera and the intestines are behind the peritoneum, so it will be understood how the testicles lying on the loins are behind the peritoneum: that is to say, the glandular substance of the testicle is invested by a coat, and that coat is the peritoneum, which, after covering the body of the testicle, is reflected upon the loins; as the coats of the liver, for example, are to be traced from its surface to the diaphragm. No words however can well explain this subject, and it will be better understood by these plans.

* The descent of the testicle was discovered, and the formation of the coats of the testicle explained, by Mr. John Hunter. See *Animal Economy*. In reading *Kerckringius* one is apt to believe he understood the nature of the descent of the testicle. Specilegium Anatomicum. p. 35.

First plan of the Testicle.



We see that the body of the testicle A is seated on the loins, that it is attached by vessels and invested by the peritoneum. This surrounding of the body of the testicle by the peritoneum forms that coat which is in union with its substance, and which descends with it into the scrotum, and forms the tunica albuginea.

The figure and presenting surfaces of the testicle, while within the belly, are the same which we find after it has descended into the scrotum. It stands edgeways forward, and the epididymis lies along the outside of the posterior edge of the testes. We see that it is attached, by the peritoneum being reflected off from its back part, and we can trace the peritoneum upwards over the kidney G, and downward over the rectum F, and bladder of urine E.

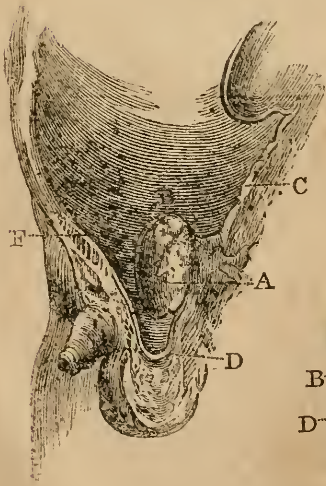
We may also observe a process of the peritoneum which has passed through the abdominal ring, and which in this plan is marked D. Now it may easily be understood that the testicle A, gradually shifting its place from its connections in the loins, drops down into this sheath D. It will also be easily understood how the testicle, covered with its first coat B, (viz. the tunica albuginea,) when it has fallen into D, is invested by this sac of the peritoneum, and that this last covering will

come to be the tunica vaginalis. The tunica vaginalis is so called because it covers the testicle like a sheath; that is, it does not universally adhere to the surface of the albuginea, as that coat does to the body of the testicle.

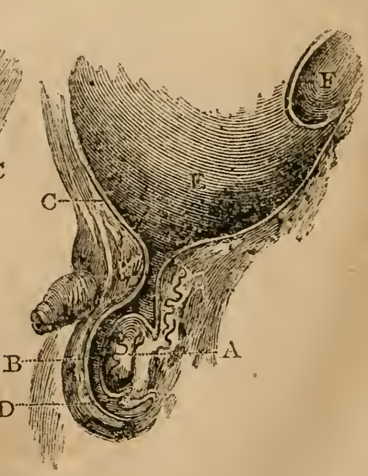
Understanding the nature of the peritoneum, we may learn the meaning of this looseness of the outer coat of the testicle. By turning to the introductory section of the abdominal muscles, we find that the inside of the sac of the peritoneum is smooth, and forms no adhesion; whilst the outer surface, being in contact with the substance of the several viscera, has a connection with them by a common cellular membrane. Now, as the inside of the peritoneum does not adhere, as the surface of the peritoneum (which in this first plan is towards C,) is smooth, and has no tendency to unite with the surface of the viscera; so neither has the surface of the peritoneum at D, the tendency to unite with the peritoneum (or the surface of the albuginea) at B, when it descends to meet it; consequently the coat of the intestines may be represented in this second plan, thus:

Second and Third Plans of the Testicle.

2d. Plan of the Testicle.



3d. Plan of the Testicle.

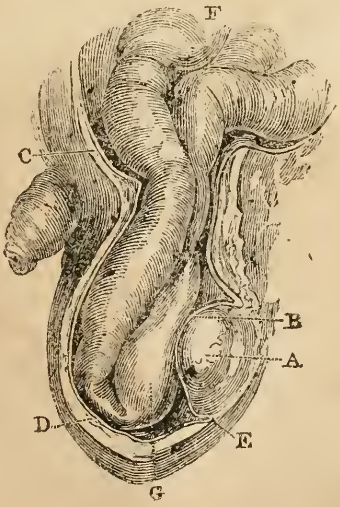


In the first plan we had the situation of the testicle in the fœtus represented. In the second plan, we have the middle stage of the descent represented: and, in the third, we have the full descent. In the second figure, A is the body of the testicle, B is the first peritoneal covering or tunica albuginea, which can be easily traced, reflected off from the loins at C; again, D is the portion of the peritoneum, which having descended before the testicle, is presently, when the testicle has fully descended, to become the second, or vaginal coat of the testicle; F is the continuation of the peritoneum upon the inside of the abdominal muscles.

In the third figure of this series, we find the testicle A has descended into the scrotum; that it has one coat covering it, which we recognise to be the same with B, in the first figure, and that the peritoneum in this third plate at B, can be traced to C, the peritoneum within the belly.

Now supposing this to be the state of the testicle immediately after it has descended, we see that there is still a communication betwixt the cavity of the tunica vaginalis D, and the cavity of the peritoneum E. F, is the kidney covered by the peritoneum, and nearly in the situation in which the testicle was before its descent.

Fourth Plan of the Testicle.



From this fourth plan of the testicle, we may learn the nature of the congenital hernia. It is a hernia produced by the intestine slipping down from the communication betwixt the general cavity of the peritoneum, and the cavity of the tunica vaginalis, or in consequence of an adhesion betwixt the testicle and a portion of the gut, which of course causes the gut to follow the testicle, and prevents the communication betwixt the belly and the cavity of the tunica vaginalis from being shut. Thus fig. 4. A, is the testicle as seen in plan 3d. B, the tunica albuginea; C, the peritoneum within the belly; D, the tunica vaginalis, which we can trace from C, and which is distended and separated from the surface of the testicle, (*i. e.* of the albuginea,) by a portion of the gut, which has descended through the ring: E, the point of reflection: F, the intestines within the belly: G, the intestine which has fallen into the tunica vaginalis, and is in contact with the testicle; that is, in contact with the tunica vaginalis, which is in close union with the gland, and is considered as its surface.

We have explained the change which takes place in the situation of the testicle, as it relates to the peritoneum; but how this change is brought about, it is very difficult to understand. It is not a sudden pulling down of the testicle, but a very gradual process, continuing for months; it is not the effect of gravitation, for the fœtus may be in every variety of posture while in the womb, and generally the head presents. It is not respiration. Is it then the effect of the action of the cremaster muscle? or must we refer it to a law such as that which controls and directs the growth of parts?

When the parts in a fœtus before the descent of the testicle are dissected, there is found a ligamentous, or cellular cord, mingled with the fibres of the cremaster muscle, and which takes its origin from the groin, is reflected into the abdominal ring, and stretches up to the body of the testicle. This body is called ligament or gubernaculum, and to the agency of this bundle of fibres, is the descent of the testicle attributed. There are, however, objections to this. If we suppose that the cremaster muscle, by its exertion, brings down the testicle to the ring, how does it pass the ring? for surely we cannot suppose that this muscle, which takes its origin from the internal oblique muscle, consequently within, can contract, not only so as to bring the testicle to the very point of its origin, but to protrude it past that point, and through the tendon of the external oblique muscle. Again, animals have the cremaster muscle, whose testicles never descend out of the belly;—again, the vessels of the cord, before the testicle has fully descended,

show no marks of being dragged down, for they are elegantly tortuous.

As the testicle passes very slowly from the loins to the ring; so, after it has escaped from the belly it passes slowly from the ring to the bottom of the scrotum. It commonly remains some time by the side of the penis, and only by degrees descends to the bottom of the scrotum.*

In this change the testicles do not fall loose into the elongation of the peritoneum like a piece of gut or omentum in a rupture;—but carrying the peritoneum with them, they continue to adhere to the parts behind them, as they did to the psoas muscle while in the loins; a point of importance to be recollected.

The communication betwixt the belly and the sac of the vaginalis is very soon obliterated by the adhesion of the upper part, and then the whole extent of the passage (viz. from E to D, in plan third of this series,) is shut. When this process is prevented in the first instance, and nature is baulked in the humour of doing her work, as Mr. Hunter observes, she cannot so easily do it afterwards.

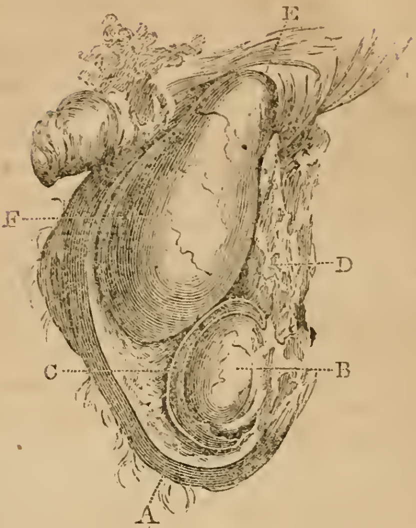
It has also occurred that, this communication remaining after birth, a hydrocele has been produced, owing to the distention of the tunica vaginalis, by fluids descending from the belly. The character of such a tumour will be, that the fluid will be easily forced into the belly. It may be mistaken for a congenital hernia.

It will already be understood, that in the common hernia of the groin or scrotum, the gut does not pass by the communication from the belly into the vaginal coat; that such communication no longer exists, and that when there is a rupture from preternatural wideness of the abdominal ring, or in consequence of a great violence, a new portion of the peritoneum decends with the gut before the cord of the testicle.

* Mr. Hunter has shown, that the detention of the testicle in the belly is in consequence of some defect and want of action in the testicle, and that those who have the testicle remaining in the belly have it imperfect or small. This is contrary to an old authority:—The testicles are seated externally, "for "chastity's sake, for such live wights as have their stones hid within their "body are very lecherous, do often couple and get many young ones."

Fifth Plan of the Testicle.

Hernia.



This fifth plan will now illustrate the relation of the testicle to the herniary sac in the common scrotal hernia. A, the scrotum : B, the testicle ; which will be easily understood to preserve its attachment to the back part of the scrotum : C, the tunica vaginalis, which here invests the testicle, but which is not now (in the adult or perfect state of the coats of the testicle,) as is seen in plan 3d, open from D to E, but forms a short sac, surrounding the tunica albuginea : D, the cellular membrane of the cord of vessels passing down to the testicle. And now there are no remains of the tube of communication betwixt the belly and vaginal cavity ; it is obliterated and resolved into this cellular membrane.

We see, then, that in this plan the testicle and its coats, and the spermatic cord, are in their natural situation, and that the herniary sac has descended before them. E, is the ring of the external oblique muscle of the abdomen, through which not only the testicle, with its coats and vessels, has descended, but also the hernia : F. the herniary sac, which contains a portion of the gut ; it is formed of the peritoneum, fallen down from the belly, but it is quite distinct from the sac of the tunica vaginalis C. Whilst this new process of the abdominal perito-

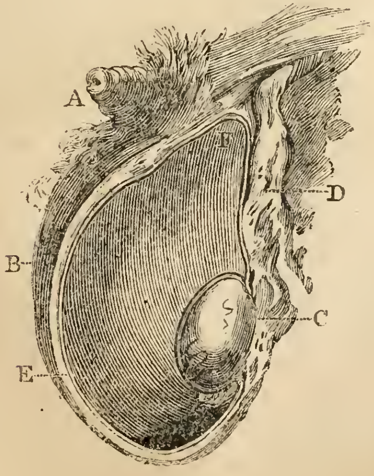
neum has descended, it has contracted adhesions, and cannot now be replaced.

In thus explaining these important principles of anatomy, and which the anatomical student will find wonderfully to facilitate the more minute study of surgical anatomy, it only remains to show the nature of the hydrocele.

The hydrocele is a collection of water within the sac of the tunica vaginalis; that is, betwixt the tunica vaginalis and tunica albuginea. For, as we have seen, that the same surface of the vaginal coat is contiguous to the surface of the testicle (viz. the albuginea,) with that of the peritoneum, which is contiguous to the viscera of the belly; and as it has the same exudation, so it has the same disease, viz. a collection of water, from the absorption being disproportionate to the exudation. When the tunica vaginalis is distended with the water of a hydrocele, the testicle is towards the back part of the scrotum; it can be felt there; and when the scrotum is placed betwixt the candle and the eye, we see the transparent sac on the forepart of the tumour, the opaque mass of the testicle behind; generally the distended vaginal coat stretches up before the cord conically: thus:

Sixth Plan of the Testicle.

Hydrocele.



A, the penis; it is generally corrugated thus, in consequence of the distention of the scrotum in scrotal hernia and hydrocele: B, the scrotum: C, the testicle, covered only by the tunica albuginea: D, the cellular membrane of the cord: E, the tunica vaginalis, distended with the water of hydrocele, and consequently separated from the surface of the testicle: F, that part of the sac of the vaginal coat, which often extends conically before the cellular membrane of the cord D. Now we see that the distention of the vaginal coat does not open up the old communication with the belly; but that the former communication being shut, and the peritoneum there degenerated into the cellular membrane of the cord, the hydrocele is a distinct sac, surrounding the testicle, and formed of the tunica vaginalis.

To understand this subject of the coats of the testicle, it is not necessary merely to consider the descent of the testicle; but the student must consider it in every point of view, turn it as it were into every variety of posture, without which his difficulties will perpetually return upon him. It is for this reason that I have endeavoured to represent the various states of the coats of the testicle in disease.

I have here used the terms *tunica vaginalis*, and *tunica albuginea*, as my reader will find them interpreted in our best old authors. But we may now inquire a little farther.

When we dissect the coats of the adult testicle, we can follow the tunica vaginalis over the surface of the testicle, and by dissecting, separate it from the testicle, leaving that body covered by a dense membrane. Specimens may be seen in my Collection, where hydatids, forming betwixt these membranes, have separated them in a manner still more satisfactory than can be done by dissection. What terms are we to use for these three membranes? 1. *tunica vaginalis;* 2. *tunica vaginalis reflexa;* and, 3. *tunica propria testis.**

OF THE VESSELS OF THE CORD AND TESTICLE.

In attending to the descent of the testicle, we have a clue also to the vascular system. If we did not know that the testicles were originally placed in the loins within the belly, we might wonder at the length and origin of the spermatic vessels.

* *De Graaff* speaks of the division of the tunica albuginea into two membranes, probably meaning to distinguish the cellular tissue of the body of the testicle from the investing membrane. *Morgagni* in his commentary on him tells us he can separate the tunica albuginea into two lamina, the inner of which was the most delicate. Advers. An. iv. Animad. i.

The SPERMATIC ARTERY rises on one side from the forepart of the aorta, below the emulgent artery, and on the other from the emulgent artery, sometimes they arise from the arteries of the renal capsule: sometimes there are two spermatic arteries to one testicle. This artery, which the cord receives from the aorta or emulgent, is called the superior spermatic artery, because there is another which rises from the hypogastric artery; this branch runs upward, connected to the vas deferens, as it rises out of the pelvis. Another artery is given to the membranes of the testicle from the epigastric artery.

These arteries, taking their course under the peritoneum, join the fasciculus forming the cord, and supply the cord, and send twigs to the investing peritoneum; they then pass through the abdominal ring, and in their course they are beautifully tortuous.

The VEINS of the testicle terminate on the right side of the trunk of the cava, a little below the emulgent vein, and in the emulgent vein on the left side. There is also (accompanying the vas deferens) a vein, which joins the internal iliac vein. All these veins, in their course from the testicle, are protected from the column of blood, and from the consequences of compression, by numerous valves. These valves are very strong, and will bear a great column of mercury before they give way or burst. This plexus of convoluted veins of the cord is the most beautiful in the body; and we may observe, that such convolutions of veins are ever attendant on arteries tortuous in their course, and subject to occasional excitement. And further, if by accident there is excited an uncommon action in the arteries of a living body, that action will be apparent from the distended or enlarged state of the veins. In the testicles of such animals as have their seasons, the artery and veins of the testicle become still more convoluted, and form a mass of vessels, which has been called *corpus pyramidale*.*

The nerves of the testicle, like the blood-vessels, come from the loins; they form a division from the emulgent plexus and are continued down upon the vessels. This connects the testicles to the abdominal viscera, giving them much of the same sympathies. The stomach, intestines, and testicle, sympathize readily with each other.

* Corpus varicosum,—Corpus Pampiniforme; Galen de Semine. Alias parastatam varicosam, Hall.—As the old physiologists saw and observed this wonderful tortuosity, and the tendril-like form of the spermatic artery, they thought that the blood was here begun to be changed into semen, and therefore they called them the *vasa preparantia*.

The lymphatics of the testicle are numerous, and easily demonstrated by blowing up the cellular structure of the body of the testicle; and this has been the ground of dispute between physiologists; and the proofs of some important points in the doctrine of absorption have been drawn from the injection of the lymphatics of the testicle and cord.

The CREMASTER MUSCLE, as we have seen in the first volume, takes its origin from the internal oblique muscle of the abdomen, from the os pubis, and passing down over the vessels of the cord, is expanded on the tunica vaginalis. The use ascribed to it is to suspend the testicle, and prevent it from dragging upon the vessels of the cord; but I conceive it chiefly useful in compressing the body of the testicle, drawing it up, and accelerating the discharge of semen.

Thus we find the cord of the testicle, as it is called, to consist of the excretory duct; of the arteries, veins, and nerves; of the lymphatics returning from the testicle; of the cellular tissue embracing and supporting all these vessels; and lastly, of the fibres of the cremaster muscle.

OF THE STRUCTURE OF THE TESTICLE.

IT is to De Graaff that we owe the knowledge of the structure of the testicle; and indeed the merit of this great anatomist has not been acknowledged with sufficient gratitude by modern anatomists: but after the fervour of disputation has subsided, the merit of ingenuity and of discovery must return to him to whom it is due. No one more highly values than I do the improvements of anatomy by the Hunters and Monro; but I must say, that the structure of the testicle was demonstrated by De Graaff to his fellow anatomists of Montpelier; and his discoveries published in a manner so perfect, as to leave us little to learn from modern authors.

De Graaff, by exciting the gland of brutes, and tying the spermatic cord, had the seminal vessels distended. He did not depend upon injections; by maceration and dissection in this distended state, he unravelled all the intricacies of their tubes. More modern anatomists have proved the truth of his observations by injections of mercury, and have succeeded in a variety of ways of preparing the testicle.

TUBULI TESTIS.—When the tunica propria testis is lifted, the body of the testicle is found to consist of innumerable delicate white tubes; which, when disentangled from the minute cellular membrane which connects them, and floated in water, exhibit a most astonishing extent of convoluted vessels. By

a closer attention, however, to this structure before it is thrown into confusion by pulling out the tubes, they appear to be regularly laid in partitions of the cellular membrane. These sepimenta are very regular in some animals, and while they separate the seminal tubes, they support and convey the blood-vessels to the secretion of the semen. Dr. Monro has denied the formal divisions which De Graaff had engraved, but admits them less regular, less easily found, and not so limited in their number; nor does he find them to prevent all communication betwixt the tubes of the testicle.

These seminiferous tubes of Haller, or tubuli testis of Monro, run towards the back of the testicle. Each of these tubes seems to be cylindrical, or of one diameter throughout their whole extent: we see no communication betwixt them; no branches given out or going into them; nor have I been able to distinguish a beginning for the whole, nor for any one of them. There seems to be only one tube wonderfully convoluted and folded up in each subdivision of the testicle.

Rete testis.—When the tubuli come out from the body of the testicle, they run along the back of it, and communicate by inosculations with each other, so as to form a network of vessels, from which appearance Haller named them rete testis.

Here it often happens that the mercury stops when it has been injected backward from the vas deferens; and it is this part which has been better described and drawn, in consequence of mercurial injections, than it was by De Graaff; for he, as we have said, saw this part only filled with semen.

Connected with the rete testis is the corpus Highmorianum.—Where the lines of the membranous septa, and cellular membrane of the testicle, meet on the back of the testicle, and under the epididymis, they form a white line. This white line running along the testicle, was supposed by Highmore to be a hollow tube; it was compared with the salivary duct; it was thought to be a cavity leading from the body of the testicle to the head of the epididymis, and to form the communication by which the semen flowed from the testicle. De Graaff first refuted this notion, and showed that it was not by this one great duct, but by these smaller tubes forming what has been now called the rete testis, that the semen came from the testicle; still it had continued a question, whether this white line was really solid, or a tube; and upon faithful examination of the point it appears, that this is expressly as it was explained by De Graaff, viz. that it is a mere collection of the membranes of the body of the testicle, forming a linea alba; and

as the septa are more distinguishable in some animals, so is the corpus Highmorianum.*

Vasa efferentia. The tubes running on the back of the testicle, and forming the rete testis, we have understood to arise from the tubuli testis ; now it is the continuation of the rete testis which is called vasa efferentia. The vasa efferentia are very delicate vessels which run out from the head of the testicle, single at first, but they are soon convoluted, and by these convolutions they are formed into an equal number of *vascular cones*, which constitute the head or larger part of the epididymis. These vasa efferentia and vascular cones are connected by a very delicate cellular membrane; and it is a piece of very nice dissection to display them after they are injected with mercury.

Epididymis.—The vasa efferentia, after forming three conical convolutions, unite and form larger tubes ; these again uniting, and form one large excretory duct, the *vas deferens ;* but this vessel, being convoluted to a wonderful degree, forms a body, which being as it were placed upon the testicle, has been called epididymis.

Seventh Plan of the Testicle.

In this representation of the dissected testicle, A is the body of the testicle divested of its coats ; B, the tubuli testis ;† CC, the rete testis ; D, the vasa efferentia ; E, the vascular cones ; F. the epididymis, formed of the convolutions of the vas deferens ; lastly, G is the vas deferens.

* This body is called a mere *firmamentum* or binding.—Winslow.

† Where the tubuli are emerging to form the rete vasculosum they are called the *vasa recta*.

In the substance of the testicle there are no glands nor follicules; the arteries minutely ramify amongst the seminal tubes, and, there is reason to believe, secrete the semen into them. The seminal vessels in the substance of the testicle, or tubuli testes, run together upon the surface of the testicle, and form the rete testis. From the rete testis are continued the vascular cones: these convolute, and running together form the epididymis; from which the tube is continued under the name of the vas deferens. It passes up the cord, enters by the ring into the abdomen, and then, passing down into the pelvis, terminates in the vesiculæ seminales, in a manner presently to be explained. It is not likely that the vis a tergo, the power of the arteries, pushes the semen through all this length of tube, of which the epididymis itself is reckoned to be several feet in length, if the various convolutions were undone; such an action on the testicle as that of the dartos or cremaster muscle, could give only a general pressure, but could not force on the semen in tubes which take so great a variety of directions. We are therefore left to the supposition, that these tubes themselves have a power of accelerating the fluids through them.

There is a duct which sometmes arises from the epididymis, and which we find to terminate abruptly in a blind end—of this, Mr. Hunter speaks in the annexed note.*

OF THE TESTICLE IN GENERAL.

The testicle is of an oval form, and of the size of a pigeon's egg; it is a little flattened on the sides: it hangs in the scrotum by the spermatic cord; one end of the oval, forward and high; see plan 8th, B; while the other is backwards, and drops

* "By a supernumerary vas deferens, I mean a small duct, which sometimes arises from the epididymis, and passes up the spermatic cord along with the vas deferens, and commonly terminates in a blind end, near to which it is sometimes a little enlarged. I never found this duct go on to the urethra, but in some instances, have seen it accompany the vas deferens as far as the brim of the pelvis. There is no absolute proof that it is a supernumerary vas deferens; but as we find the ducts of glands in general very subject to singularities, and that there are frequently supernumerary ducts, there being often two ureters to one kidney, sometimes distinct from beginning to end, at other times both arising from one pelvis; these ducts arising from the epididymis, I am inclined to believe from analogy, are of a nature similar to the double ureters. They resemble the vas deferens, as being continuations of some of the tubes of the epididymis, are convoluted where they come off from it, and afterwards become a straight canal passing along with it for some way, when they are commonly obliterated.

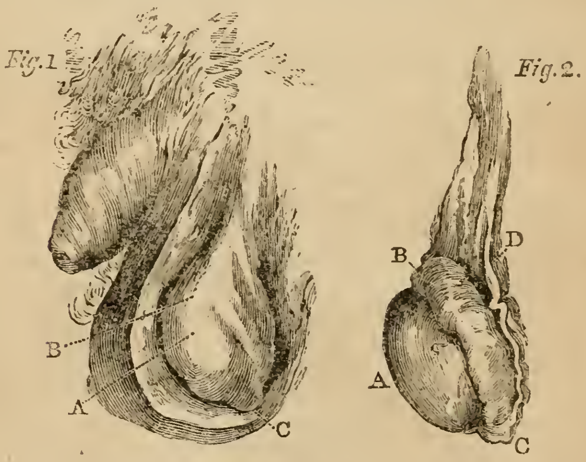
"The idea of their being for the purpose of returning the superfluous semen to the circulation is certainly erroneous, from their being so seldom met with, and so very seldom continued further than the brim of the pelvis." Many examples of this may be seen in my Collection.

lower, C. The spermatic cord consists of the artery which brings blood; of the veins which return it; of the vas deferens, which carries the semen to the vesiculæ seminales at the neck of the bladder; of lymphatics, which are essential to the structure of every part. This cord of vessels comes down from the belly, and passes by the ring of the abdominal muscles: it is about four inches in length, and is fixed into the upper and forepart of the body of the testicle.

The body of the testicle is easily distinguished, and is the place where the secretion is performed. It is strictly the body of the gland, while the part above it is only the duct by which its fluid is discharged.

The ancients called the testicle dydimi, gemini, twins; they, therefore, called that part which is laid on the back of the testicle epididymis, as added to it. To the surgeon, it is essentially necessary to attend to the relation of the parts of the testicle as felt through the scrotum.

Eighth Plan of the Testicles.



In this 8th plan, fig. 1. we see the testicle as in its natural situation, covered with its membranes, and appearing like one body; while, in the second figure, it being represented freed from its outer coat, we see the epididymis as laid upon the testicle, and consisting of the convoluted tube. First, we observe A, the body of the testicle: B, the beginning of the epididymis, or the large head of the epididymis:* then we see it laid along the back of the testicle, and observe C to be the

* *Globus major*, or head.

small head of the epididymis,* where the tube is reflected to reascend upon the testicle, and to form D, the vas deferens.

Now, we have to observe, that the point C, fig. 2. or small head of the epididymis, hangs over the testicle, and points backwards to the perineum, and can be felt through the whole coats : and that the body of the testicle A, is towards us when we examine a patient.—Further, as the letters in figure 1. and 2. refer to the same points, we have only to notice the fainter indication of the parts in fig. 1. it being invested with the coats, and to observe the general relation of the testicle to the scrotum and penis.

There is one other circumstance to be observed, viz. that the epididymis is always laid on the outer side of the insertion of the cord into the testicle ; from which we distinguish, with ease, in a preparation, to which side the testicle belongs. Thus, in the annexed plans, the testicle of the left side is represented, which we know from the points C, being directed backward, while the epididymis is laid along the left side of the insertion of the cord.

OF THE VESICULÆ SEMINALES.

Behind the prostate gland, and attached to the lowest part of the urinary bladder, lie two soft bodies, the vesiculæ seminales. They appear like simple bags when seen from without, but dissections show them to consist of cellular structure : each of these bodies is about three fingers-breadth in length ; their backmost point is large and round, and, at the same time that they diverge from each other, their narrow points unite, or are contiguous to each other forwards, and enter at the back part of the base of the prostate gland.

As we have seen, the peritoneum does not descend far enough betwixt the bladder and the rectum to cover or invest these vesiculæ : they are therefore involved in the cellular texture, and covered with strong fibres, besides being subject to the compression of the levator ani muscle. When the vesiculæ are cut into, and especially when they are distended, dried, and cut, they appear cellular , but if they are carefully dissected, they present the appearance of a convoluted duct.

This cellular appearance is given by the duplication of their inner membrane, together with the distortions and curves of

* *Globus minor.*—This part we often distinguish retaining its hardness after the subsiding of the general swelling of hernia humoralis. From this point we can trace all the connections of the other parts.

the canal. Their outer surface is covered with a fine membrane, which connects these cellular convolutions.

The vesiculæ are copiously supplied with arteries ; their surface is covered with veins and lymphatics. Hiester, Winslow, and others have described small glands seated in their sinuosities ; but these are confidently denied by others. These vesiculæ are themselves glands, or in other words, the arteries secrete into them a peculiar fluid. The forepart of each of the vesiculæ, which we have said sinks into the back part of the prostate gland, runs under the neck of the bladder, and opens by a distinct mouth into the urethra on the surface of the verumontanum.

The connection of the vas deferens with the vesiculæ is very particular : the duct and the extremity of the vesicular tube join, and they together open into the urethra. There is nothing in the human structure to discountenance the idea that the semen may pass retrograde from the vas deferens into the vesiculæ seminales, but as in some brutes the vas deferens has no connection with the vesiculæ seminales, it is to be presumed that they are not mere receptacles of the secretion of the testicles.*

The extremity of the vas deferens joins the duct of the vesiculæ where it is imbedded in the prostate gland ; the union of the vas deferens and duct of the vesiculæ is not attended with an enlargement of the duct ; on the contrary, as the duct passes forward deep into the substance of the gland to arrive at the urethra, it becomes remarkably narrower until it opens in a very small orifice in the verumontanum, as we see represented in the third plate. The duct (if we may so call it) of the vesiculæ passes a full inch forward into the gland before it terminates in the urethra.

The vesiculæ appear to be useful in adding a fluid to the secretion of the testicle, which being poured together into the sinus of the urethra, are then sufficient to distend this part of the canal, by which too the ejaculator muscle is exerted and effect given to its action ; for a smaller portion of fluid would not be carried forward by its contraction, unless there were a provision of fluid sufficient to distend the sinus of the urethræ, the semen could not be thrown out from the urethra. This supposition is not opposed by the facts stated by Mr. Hunter, that in many animals the vesiculæ and vasa deferentia open by distinct foramina into the urethra, because in that case the fluids of these secreting bags might be equally mingled with

* See explanation of plate III.

the semen in the sinus of the urethra, although they do not flow from the same tube.

Verumontanum.—The verumontanum or caput galinaginis, is an eminence on the lower part of the urethra, where it is surrounded by the prostate gland. It is larger and round towards the bladder, and stretches with a narrow neck forwards. On its summit, the two orifices of the seminal vessels open; and around it there are innumerable lesser foramina and mucous follicules, the duct of the prostate gland.

The sinus pocularis is the sac or large lacuna formed within the caput galinaginis; its mouth is directed forwards, so that the urine flowing out of the bladder lays the margin down, the seminal orifices open within the margin, and they are by this means protected from the urine. Sometimes the ducts are found opening on the sides of the sinus.

THE

ANATOMY

OF THE

FEMALE PARTS OF GENERATION.

THE ANATOMY OF THE PARTS IN THE FEMALE PELVIS.

THE parts of generation are divided into the external, which are those without the pelvis; and the internal, or viscera of the pelvis, and which lie within the bony circle of the pelvis.

CHAP. I.

THE EXTERNAL PARTS OF GENERATION.

THE external parts of generation are the mons veneris, labiæ, clitoris, nymphæ, urethra, hymen, and carunculæ myrtiformes. Upon these subjects we have no want of books and information; for accoucheurs of the old school dwelt upon the description with particular accuracy. These parts were within their ken, which we cannot say of the viscera of the pelvis; and therefore upon this first head we shall be more brief.

In very young children these external parts bear a large proportion to the body, greater than at any subsequent period

before the age of puberty. At puberty they are suddenly and completely evolved, and acquire an increase of size; while, from the age of two years to twelve or thirteen, there has been little increase. Preceding menstruation is the development of the uterine system: the whole parts internal and external partake of a sudden impulse.

The parts become turgid and vascular; the fat is deposited in the surrounding cellular membrane. About the fortieth year, when the menses disappear, this fulness of the private parts also ceases, and the fat is re-absorbed.

The MONS VENERIS is that prominence on the symphysis pubis, which consists of the skin raised and cushioned up by the fat inclosed in the cellular membrane. There is a great variety in its size. In early life it is small: it becomes, as we have said, more prominent at the age of puberty; in fat women it is of an enormous size; and in some warm climates a particular laxity prevails. From the hair on this part, marking the age of puberty, it is called pubes. As the lax texture admits of distention with the fluid of anasarca, it is sometimes from this cause very greatly swelled.

The LABII.—These are often named alæ, from a slight resemblance to wings, and they are also called externæ, magnæ, or majores, from their place, and from their superiority in respect of size over the nymphæ. The labii seem to be the mons veneris continued downward and laterally, until meeting below, they form the vulva; at their lower angle by their union they form the fourchette, or frenum labiorum. The structure of the labiæ is similar to that of the mons veneris; sometimes one is larger than the other.

The great sensibility of the membrane which lines the inside of the labii requires some defence, and therefore the whole surface is amply supplied with mucous follicules and glands. The labii are a protection to the other soft parts, so necessary, that the clitoris, or nymphæ, when they project beyond them, are subject to violent inflammation.

The parts here have either such folds, or are of so lax a texture, as to permit a great degree of distention during the passage of the child. But as the labii have no muscular power, and depend entirely on their elasticity for restoring them to their original size, they commonly, after being very much dilated, remain in some degree larger and more lax. It is different with muscular parts, as the orificium externum, which, by the power of its sphincter, is restored after labour to its original size. In man, hernia descends from the abdominal ring

into the scrotum : but in woman, when there is a rupture from the ring (which is rare) it falls into the labium.

The NYMPHÆ are named labii vel alæ minores, or labiæ internæ, to distinguish them from the great labiæ. They are like a miniature representation of the great labiæ; they are covered with a very delicate membrane, and have great sensibility. They begin immediately under the glans clitoridis, and seem to be only an extension of its preputium, formed by a folding of the membrane. Their size varies much. They commonly stretch downward and backward, to the middle of the orifice of the vagina; sometimes no further than to that of the orificium urethræ, and in a few instances they extend even in the length of the fourchette.* They are very vascular, and have somewhat of a cellular structure, and thus partake of a degree of turgidity, in consequence of irritation and vascular action. The most modest of the uses ascribed to them is, that of directing the stream of urine. As they are obliterated during the passage of the child's head through the vulva, it is probable that they facilitate the necessary dilatation.

The nymphæ are, in their natural situation, covered and completely protected by the labii externi. When naturally large or increased by disease, or in a very relaxed state, they are deprived of this covering: they project from under the labii, and are apt to become inflamed, and even to ulcerate. The original disease, or tumour is augmented, or they become perhaps hard and callous. In children they bear a very great proportion to the other parts, and are more conspicuous and prominent than in the adult. Their diseased enlargement sometimes requires to be extirpated, in which operation, as they are very vascular, and as with their growth, their blood-vessels enlarge, considerable hæmorrhagy may be expected.

The CLITORIS is similar to the male penis. Like the penis, it consists of cells for receiving blood, and in a similar manner, it arises from or takes hold of the rami of the os pubis by two crura; these unite at the symphysis pubis, to form the body of the clitoris, which is suspended from the os pubis, like the penis, by a kind of ligament. The clitoris has also a kind of glans, over which the integuments make a fold like a preputium. In short, it has the same sensibilities, the same power of erection with the membrum virile; only it has no urethra nor spongy body, like that of the urethra of man.

The stories of the increase of this, even to its pre-eminence in size over the male penis, are very idle, but there seems to be a peculiar predilection for them. It is not wonderful that

* Both Riolin and Morgagni have seen the parts without the nymphæ.

a clitoris of such magnitude should suggest the idea of a hermaphrodite, or person partaking equally of the distinguishing attributes of either sex.

OF THE URETHRA.

The urethra of the female is short, straight, and wide; its length an inch and a half, or two inches; its direction nearly straight, or only slightly bending under the os pubis; and its diameter such as will admit a catheter the size of a writing quill. The consequences of these peculiarities are, that the catheter is easily passed when there is no very unusual obstruction; that women are not so much exposed to the disease of stone in the bladder as men, for though this is much owing to constitutional peculiarities, yet it is obvious, that where a small stone is formed, and passes from the bladder, it is easily discharged. If it does not pass with the flush of urine, yet the canal may be dilated, so that a very considerable calculus may be discharged without incision.

The opening of the urethra is in a direct line under, or behind the clitoris, and about an inch from it: it is in the middle of a straight prominence, and its vicinity is plentifully supplied with mucous glands. If the relation of the orifice to the clitoris be observed, there is, in the natural state of the parts, no difficulty in slipping the point of the catheter, on the end of the middle finger, from the clitoris, until it is caught upon the lacuna-like orifice of the urethra; but even in this part of the operation, I have experienced great embarrassment, from an irregular ulcerated or cancerous surface of the parts, by which all the usual distinctions were lost.

From the length and sudden turns of the male urethra, from the double function it performs, and from its being embraced by the prostate gland, the obstructions of the urine are more frequent, and the catheter less easily passed than in woman. The catheter too requires to be of a very peculiar form. The short and wide urethra of woman requires only a simple and almost straight tube: and although accurately to adapt it to the course of the urethra, a considerable curve might be given to it, yet that is not necessary in common cases; and circumstances will occur to the accoucheur which will preclude the possibility of using such an instrument.

We shall only mention here such cases of obstruction of urine as are in a particular manner illustrated by the anatomy and connection of the parts. These are tumours of the ovarium, tumours of the womb, polypi, distention of the vagina,

displacement of the womb, as procidentia, prolapsus, retroversio, &c.; and lastly, the child's head in labour.

The ovarium being enlarged, and falling down into the pelvis, either presses upon the neck of the bladder, causing obstructions, or pressing and weighing on the fundus of the bladder, it occasions a stillicidium urinæ.

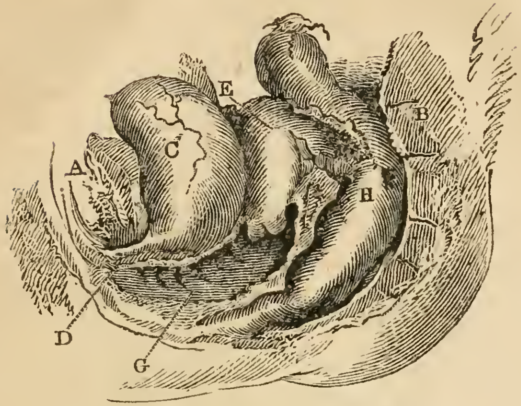
Tumours of the womb, especially of the neck or orifice, as it is in contact with the urethra, very soon affect this organ. Thus, I have seen a cancer of the orifice of the womb, by exciting inflammation in all the surrounding parts, and by massing them together into a tumour filling the pelvis, occasion obstinate obstruction of urine.

Polypi attached to the orifice of the womb, and filling the vagina, produce the same effect. In all such cases, perhaps, the tumour may be pushed up, so as to permit the flow of urine, or the introduction of the catheter.

A case occurred to Mr. John Bell, in which the tumour of the womb compressed the neck of the bladder. A catheter was passed, and gave instant relief. The midwife, after some time, came, and said, that the catheter would not pass. He found that he could pass the catheter into the bladder, but no urine flowed; and it was discovered, that the tumour, increasing backward, came to press upon the ureters, so as completely to obstruct them where they enter the bladder. The woman unavoidably died; each kidney and ureter was found to contain four or five ounces of urine.

A slight sketch of the parts in the female pelvis will, perhaps, better explain the connections of the neck of the bladder than any description, and will certainly better illustrate the cause of some kinds of obstruction, particularly that arising from the change in the posture of the womb.

First Plan of the Female Pelvis.



A, the os pubis cut through; B, the spine and sacrum also cut directly down; C, the urinary bladder moderately distended, and rising behind the pubes; D, the urethra, very short, and taking a gentle curve under the symphysis of the os pubis; E, the fundus of the womb; F, the os tincæ, or orifice to the womb; G, the vagina; H, the rectum.

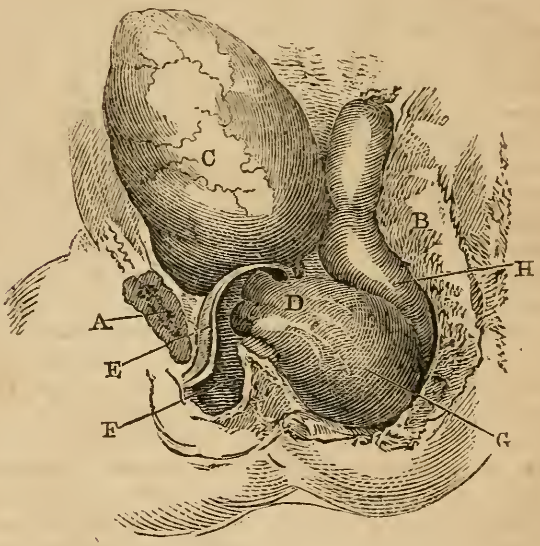
Prolapsus, or falling down of the womb, is frequent with those who have borne many children. By this slipping down of the body of the womb F, into the vagina G, it presses on the neck of the bladder, or urethra. This is also apt to happen in the first months of pregnancy, from a degree of difficulty which the womb in its enlargement has in rising above the brim of the pelvis.

We may observe also from the place of the vagina G, that its diseases, its scirrhous hardening, its distention by the menses, will also compress the urethra and neck of the bladder.

The retroversion of the womb is the most formidable obstruction to the urethra. It is produced by distention of the bladder acting on the womb in a particular situation, and is the cause of suppression of the urine. When the womb in the third or fourth month of gestation has increased so much as to produce a degree of compression on the surrounding parts, and to rise above the brim, and shoot up into the abdomen, a distention of the bladder is apt to throw the fundus under the projection of the sacrum. We have to observe the connection

betwixt the back and lower part of the vagina. By the distention of the bladder, the vagina is stretched, and the orifice of the womb is raised, which throws back the fundus of the womb, so that this comes to be the situation of the parts.

Second Plan of the Female Pelvis.



A, the os pubis; B, the sacrum; C, the bladder of urine much distended, and rising above the pubes; D, the connection betwixt the back part of the bladder and the upper part of the vagina, and through which the rising of this part of the bladder (in consequence of its distention) has drawn up the orifice of the womb, and thrown back the fundus. E, the orifice of the womb, which being raised and turned up, no longer presents so as to be felt by the finger in the vagina. It will be observed also, that the womb now lying across the pelvis, this lower part is forced against the neck of the urethra, so as to compress it, and cause total obstruction of urine. F, the vagina, which is stretched in consequence of the rising and turning up of the orifice of the womb. G, the fundus of the womb enlarged and distended by impregnation, fallen

back under the promontory of the sacrum, and compressing the rectum H.

Now, when the fundus of the womb is thrust back, and the orifice raised by the distention and consequent rising of the bladder, the natural and simple cure is to introduce the catheter, and draw off the urine. But should this not be done at first, then there being distention of the bladder, and pressure on the rectum, the abdominal muscles sympathize with these parts, so that bearing-down efforts are made, and the fundus of the womb is forced further down into the hollow of the sacrum, while the orifice is directed upward.

Were this distention to happen at any other time than just when the uterus is of such a size, that, being thrown back, it catches under the sacrum, and does not rise again, no harm could follow.—I last year attended, with Mr. Cheyne, senior, a woman afflicted with obstruction of urine, who died. I afterwards opened the body, where the womb, being enlarged by disease, had produced much the same effect as if it had been enlarged by pregnancy, viz. obstruction of the urethra; for the body of the womb had fallen into the hollow of the sacrum, and had formed adhesions there with the rectum, while the orifice of the womb pressed forward upon the os pubis, so as to produce an obstruction of the urine. The parts were otherwise diseased, and this was one cause of the obstinacy and fatal determination of the complaint.

As we treat of those subjects only as connected with the urethra, we may observe, that sometimes the urethra takes a course, not round behind the os pubis simply, nor straight upwards, but curved backwards, so that the convexity of the catheter requires to be towards the sacrum, to allow the point to pass over the orifice of the womb, or perhaps the flexible or the male catheter may be required.

The effect of the wedging of the child's head in a tedious labour, is to elongate and compress the urethra in a very particular manner. Many young men have felt the difficulty of introducing the catheter in this case. But it is a difficulty proceeding generally from ignorance or inattention. I believe there never occurs a case in which the child's head is so firmly impacted, that the catheter cannot be passed. But often practitioners forget the direction which the urethra necessarily assumes, when the child's head has sunk into the pelvis.

Orificium vaginæ.—This is also named orificium externum, in distinction to the uterine orifice. I notice it under the head of the external parts, because we have to speak of the parts which surround the orifice, as the hymen.

All anterior or external to the orifice of the vagina and

within the labii is the vestibulum. The orifice of the vagina of the human female is abridged by the hymen, which is a peculiar membrane. It is of a semilunar form, and sometimes surrounds the lower part of the orifice of the vagina;—commonly it surrounds only the lower half of the circle, though it would seem to vary considerably in shape, place and strength. It has been found surrounding the whole circle of the orifice, leaving only a small hole in the centre or upper part; or it is described as perforated with lesser holes, allowing the evacuation of the menstrual blood. In other cases, it has been found a complete septum, preventing the evacuation of the menstrual blood.—This is a fact which I do not dispute, for I know that the perforation for the evacuation of the menstrual blood is sometimes necessary. When I have seen the imperforated vagina in the child, it was not the hymen which closed the orifice, but an adhesion of its sides; yet this adhesion, if it had come to be distended with the menstrual blood of several periods, would have presented the appearance of a tense membrane stretched across the orifice.

Such semilunar membrane as I have described, will occasionally be seen in the female parts; but it has such an appearance as may be easily destroyed in the preparation of the parts, if the anatomist be inattentive or careless. It is neither a guard, nor is its existence a test of female chastity. Often in tender children there is no such thing to be seen; while, on the other hand, it has been cut to admit of labour and delivery.* Either of these facts is sufficient proof of the idle notions entertained concerning this membrane, and that when present, it is, like a contracted preputium in the other sex, a defect.

The CARUNCULÆ MYRTIFORMES—are small and irregular tumours at the back, or lower part of the external orifice; they are seated rather at the sides than exactly at the back part; they are supposed to be the ruins of the hymen, which being lacerated, shrink into two or three tumours on each side. Some have said, that these exist originally joined together by a thin membrane, or delicate tissue of small vessels, the rupture of which causes an effusion of blood. They seem to be simply corrugations of the inner membrane, which serve as a provision for the dilatation of the parts; and they accordingly disappear during the passing of the child's head.

The FOSSA NAVICULARIS is a sinus, supposed to be of the shape of a boat, whence its name. It is formed betwixt the

* I need not say how unnecessary and improper such operations are. All rigidity, callosities, even tumours, and undoubtedly the hymen, will yield to that general relaxation of all the parts, which takes place upon the commencement of labour.

proper orifice of the vagina and the fourchette, or joining of the labii at their lower edge. It is more conspicuous in young subjects.

From the meeting of the labii below, the PERINEUM commences: it includes the space from the frenum to the anus.

CHAP. II.

OF THE PARTS CONTAINED WITHIN THE FEMALE PELVIS.

THESE parts are, the bladder of urine, the vagina, the womb, the ovaria. We shall consider them under distinct sections.

SECTION I.

OF THE BLADDER OF URINE.

As the coats of the bladder of urine in woman do not vary from those of the male bladder, we have under this head only to notice the peculiarities in its relative situation. It is seated behind the os pubis, and betwixt it and the womb; and on its lower part it is attached to the vagina; upon the neck of the bladder, or the beginning of the urethra, there is not a body like the prostate gland; and, as we have seen, the urethra is short, wide, and straight, and simple in its use.

Women are not subject to calculi, and the operation for the stone is rare in them; for, as already observed, when the nucleus is formed, or when a stone slips down from the pelvis of the kidney, it passes from the bladder with much greater facility than in the male parts. The urethra of itself has been known to dilate so as to allow very large stones to pass, or it has been artificially dilated. Indeed the old operation for lithotomy was rudely to dilate, or rather tear, the urethra, and the modern operation is simply to thrust the gorget along the grooved staff, so as to lay open the side of the urethra and neck of the bladder, by an incision above the vagina. Sometimes nature has effected her own relief by the stone working from the neck of the bladder into the vagina.

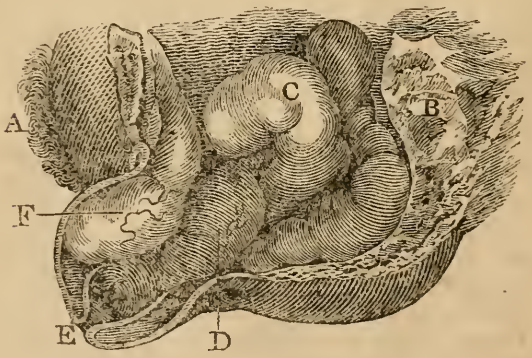
A woman had for a very long period suffered great distress, not only the ardor urinæ, frequent desire to make urine, with

the urine turbid and bloody, and with all the usual symptoms of stone violently aggravated; but she was delicate and timorous, and concealed her distress, until the urine had run for some time by the vagina. After she had been exhausted by long suffering, her friends insisted that she should allow an examination, when a stone was found partly in the bladder, with one of the rough ends projecting into the vagina. The opening was enlarged, and the stone extracted.

We must, in all cases, recollect the connection of the upper part of the vagina and orifice of the womb, with the back part of the bladder. We have seen its effect in producing retroversio uteri. We must also attend to this connection, as tending to the displacement of the bladder in the procidentia uteri. The uterus sinking into the vagina, and the upper part of the vagina being at the same time reflected into the lower part, pulls down the bladder with it, and when (the disease increasing) the womb covered by the vagina comes to hang from the external parts, it has happened that the bladder has sunk down and lain upon the forepart of the tumour, but of course within the everted vagina.

Third Plan.

Section showing the effect of Procidentia on the Bladder.



Thus, by comparing this fourth plan with the first of the female pelvis, we may judge of the nature of this displacement of the womb, and its effects on the bladder of urine.

A, the os pubis; B, the sacrum; C, the intestines come into the situation of the womb; D, the uterus fallen down, and carrying the vagina before it; E, the vagina still covering the womb, but the orifice of the womb appearing, which is

generally distorted and irregular; F, the bladder, which, from its attachment to the forepart of the vagina, has been dragged down, but is now within the vagina.

In such displacement of the bladder, the urethra becomes distorted from its natural direction, there is an obstruction of urine, and the catheter is with great difficulty introduced. We shall, perhaps, have to turn the handle of the catheter in various directions after introducing the point, and by chance get it introduced at last.

SECTION II.

OF THE VAGINA; OF ITS SHAPE, CONNECTIONS, &c.

The vagina is a tube stretching from the external orifice to the orifice of the womb. Its orifice is bounded below by the fourchette; above by the arch of the pubis; and directly over it, or sometimes within it, is the orifice of the urethra; below, are the carunculæ myrtiformes. It is surrounded by fasciculi of fibres, which are called the sphincter muscle. The canal of the vagina is of a conical form. At the outer orifice it is constricted by the sphincter muscle: but it is wider within, and where it receives the orifice of the womb. It may be distended to almost any degree, but naturally its sides, by their own elasticity, the fulness of the veins which are upon it, and the contraction of the surrounding fibres, are in contact.

In the natural state, the orifices of the vagina and womb are but three or four inches distant, often only two; and sometimes, where there is a degree of relaxation, they are nearly in contact. In the first months of pregnancy, the orifice of the womb is kept down by the degree of difficulty the body of the womb has in shooting up from the brim of the pelvis. But the gravid uterus rising above the pelvis in the latter months, draws up the orifice of the womb and stretches the vagina.

The vagina bends gently round the pubis, as it were, or follows the axis of the pelvis; and as the interior of the two circles cut off by the same radii s the shorter, the vagina is longer behind than before.

And thus (*in this fourth plan*) the forepart of the vagina A, is shorter than the back part B. We may observe from this plan, also, that the orifice of the womb C, projects as it were into the vagina, so that the finger touches the os tincæ, and chiefly its anterior lip, without reaching the upper part of the vagina.

The vagina takes its curve nearly in the centre of the pelvis; it is of necessity attached by cellular substance to the rectum and bladder. The urethra, as we have said, opens above the orifice, and that canal is attached to the vagina in its whole length; and the neck of the bladder is attached to the upper part. In consequence of this natural connection, disease of the vagina sometimes throws the whole parts, the rectum, vagina, and bladder, into one fistulous ulcer.

The vagina has three coats; that is to say, it has the inner coat, or surface, a few muscular fibres, and around it a condensation of the surrounding cellular membrane, which may be considered as the third coat.

The internal, or villous coat, is a reflexure of the delicate covering of the external parts. It is of larger extent, or longer than the others; and is therefore tucked up into rugæ, which run across the vagina. They are more remarkable on the fore and back part of the vagina; they are less in married women, and considerably obliterated by repeated labours.

To supply a viscous secretion for the defence of this surface, mucous glands are numerously, but irregularly, scattered over it, and they are particularly numerous at the orifice.

The muscular coat is not very strong, nor are the fibres dis-

tinct, from which some have suspected their existence, alleging, that there is here only condensed cellular membrane, and that the contraction of the vagina is the effect of mere elasticity. I observe so great a profusion of venous vascularity, that I presume the vagina suffers an inflation of its coats, and consequently contraction from an afflux of blood to it. The muscular fibres are, however, as we have said, gathered into fasciculi near the orifice, so as to be distinctly visible.

The firmness and structure of the vagina supports the womb; the dilatation of the vagina, the relaxation which old age, and frequent labours produce, occasion the falling down of the womb. It is a disease almost peculiar to those who have borne many children, to the old, weak, and relaxed, and to those who are subject to the fluor albus; every flux from the womb, or discharge from the vagina, having a remarkable effect in relaxing the parts.

This, from the nature of the parts, must be an increasing disease; for no sooner has the womb fallen down into the vagina, than it becomes a source of irritation, excites a bearing-down pain like tenesmus, an uneasy sensation, a desire to make urine, and an obstruction of urine; all which is explained by the connection of the parts. The womb lodging in the vagina dilates the orifice, and presses long on the perineum, at last it is entirely forced out, and the prolapsus uteri becomes the procidentia uteri: it is in truth a hernia of the womb.

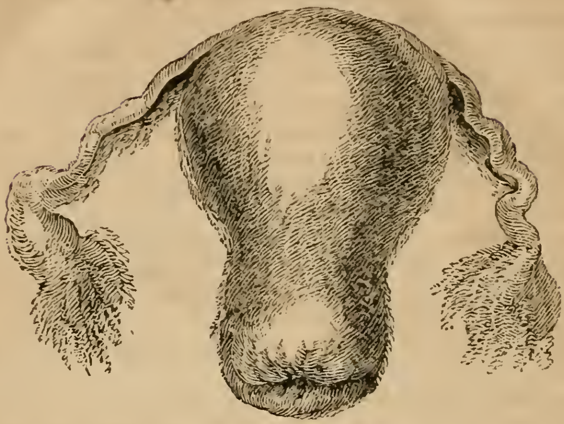
The third, and outer coat, as we have said, is formed of the cellular membrane, by which it is connected with the surrounding parts; but the peritoneum comes down upon the upper part of the vagina. This is the reason why a portion of the intestine, when it slips down betwixt the vagina and rectum, forms a kind of hernial tumour in the vagina, and why the water of the ascites has pushed down the back of the vagina, so as to make a bag capable of being punctured to draw off the water.

For the greater space, however, the outer cellular coat of the vagina connects it with the urethra on the forepart, and with the rectum behind. From which close connection of parts, we see the consequence of the delay of the child's head in the second stage of labour, that the head lies violently distending, and compressing the parts, while the woman, exhausted by the previous stage, is unable to complete the delivery. From violent inflammation, with a deficiency of secretion, there arises a cold and flabby state of the parts. When the woman is delivered, the parts have suffered so much, that they slough off; sometimes the urethra is laid open on the forepart, and sometimes the rectum behind.

SECTION III.

OF THE WOMB.

Fifth Plan of the Female Parts.



Uterus and Tubes.

This little drawing will better explain the figure of the womb, when dissected from the vagina and surrounding membranes, than the usual reference to a bottle, a pear, or a powder-flask. As, indeed, it resembles no familiar object that I know, we must, for the convenience of description, distinguish it into these parts :—The upper part, or FUNDUS, which is that part above the going off of the Fallopian tubes. The BODY of the uterus, which is that larger part betwixt the fundus and the narrowing below; THE CERVIX, which is the narrow neck; and the OS TINCÆ, or orifice formed of the bulging lips, which project into the vagina, of course that part over which the inner membrane of the vagina is reflected. We distinguish also the two surfaces, for the womb is of a flattened form. The anterior surface of the body of the womb is convex, but the posterior surface is considerably more so, and even during gestation it keeps this relative figure.

The whole size of the uterus is about three inches in length, and two in breadth, but there is a very great variety in this respect, from age, the effect of pregnancies, and other causes. When in its usual situations and relations, the fundus is on a level with the brim of the pelvis, or a very little below it. In the fœtus, the womb is like the bladder, considerably above the brim of the pelvis; but in a few weeks the pelvis enlarging,

it sinks deeper and soon assumes the same situation as in the adult.

Fallopian tubes. From the lateral obtuse angles formed betwixt the fundus and the body of the uterus, the Fallopian tubes are continued. These tubes may almost be considered as a continuation of the uterus did not we find them so very distinct in their substance. They are about three inches in length, take a tortuous course, and their extremities have an unequal fringed termination, which is called the fimbriæ.* Their canal is very small towards the uterus, but enlarges; and is patulous towards the extremities. These canals are the communications by which the ovum formed in the ovarium is carried down into the womb.

Ligaments of the uterus. To support the uterus from sinking too deep into the pelvis, and to steady it, and direct it in its ascent during pregnancy, anatomists have generally assigned as the use of the ligaments. But whatever good they may do in the latter operation, they are certainly unfit for the former.

There are four ligaments of the uterus.

The broad ligament of the uterus is formed of the peritoneum; for this membrane passing down before the rectum, and ascending again, and covering the neck, body and fundus of the womb, descends on the forepart, so as to reach the vagina before it rises over the bladder. Thus it invests the womb as it does the abdominal viscera. This investing of the womb with the peritoneum is indeed a provision for its becoming an abdominal viscus, for in pregnancy it rises out of the pelvis; and being distended before the bowels, assumes in every respect that relation to the peritoneum which they have.

As the womb is included betwixt the duplicature of the peritoneum, it is this peritoneal coat, which being continued off laterally, forms the broad ligament of the womb. This duplicature of the peritoneum being a thin expansion of it, has sometimes had the name of alæ vispertilionis: it is in truth like a mesentery to the womb and Fallopian tubes, and serves equally to support and convey the vessels to them. The womb and these two ligaments make a complete partition running across the pelvis.

From the side of the uterus, a little below, and before the going off of the Fallopian tubes, the round ligaments arise. They are not merely condensed and elastic cellular membrane; but are composed of fibres with an intermixture of blood-vessels, so that whilst they keep a degree of tension on the uterus, they yield and grow not only in length, but in thickness and

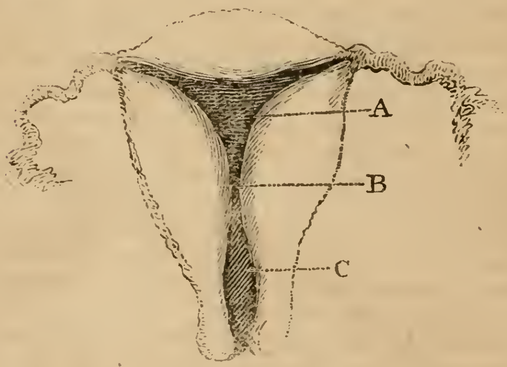
* Morsus diaboli.

strength, as the uterus ascends in the advanced pregnancy: they pass through the abdominal ring, and are attached to the cellular membrane of the top of the thigh. In the gravid uterus, both the broad and the round ligaments considerably alter their position, appearing to rise lower, and more forward from the womb than the unimpregnated state. This is in consequence of the greater increase of the fundus of the womb, in proportion to the lower part of it.

What I have here described, and which are commonly called the round ligaments of the uterus, are the tendons of the ligaments, and have a very particular use which authors have not observed; at their upper extremity they terminate in a muscular coat, which is spread over the fundus of the uterus diverging from the tendon. The use of these tendons is to move the uterus in the first approach of labour, and to present the orifice of the uterus to the axis of the pelvis.

OF THE CAVITY OF THE UTERUS.

Sixth Plan.



The cavity of the uterus is properly confined to the fundus and body, and takes a triangular figure. In the cervix, it is more like a canal, and differs essentially from the proper cavity. A, *the cavity of the uterus;* B, *the continued cavity*, where it is very narrow towards the cervix. C, *the canal of the cervix*, where it has an enlargement like a sinus. The Fallopian tubes are seen going off from the cavity of the uterus. These angles of the cavity admit no more than a hog's bristle. The third angle, towards the neck, is, of course, considerably larger. The proper triangular cavity of the uterus is lined with

a peculiar soft and delicate membrane; it is very vascular, and the vessels either open on the surface naturally or bursting out, from time to time, pour out the menstrual blood. The canal of the cervix shows a very different surface. We observe a prominent longitudinal line on the fore and back part of it, from which oblique and transverse rugæ go out. The surface is firmer and callous, and less vascular. Betwixt the rugæ there are lacunæ, which throw out a mucilaginous fluid; and towards the orifice we see these larger and sometimes distinct glandular bodies.

This peculiar shape of the cavity of the womb, and the hardness and small degree of vascularity of the lower part, is of the most essential importance. The upper part, the proper cavity of the womb, is prepared for the reception and immediate adhesion of the ovum, when it shall have descended through the Fallopian tube; but the long callous cervix is provided, that there may be no adhesion to the lower part of the womb, and that the placenta may not form over the orifice of the womb, for if it should, the most dangerous kind of flooding takes place on the approach of labour, from the opening of the orifice, and the tearing open of the adhesions of the placenta, before the child can be delivered. The length of the cervix, and the glandular structure of the orifice, is also of much importance in sealing up the cavity of the womb after conception, that there may be no longer communication with the vagina; for this purpose, a viscid tenacious mucus is poured out; but, on the approach of labour with the softening and relaxation of all the soft parts, this adhesion and gluing up of the orifice is dissolved, and a more fluid secretion is poured out.

From the cavity of the womb the MENSTRUAL BLOOD is discharged at certain periods, from the time of puberty to the approach of old age, when the system is no longer capable of giving nourishment to the fœtus.

It was long disputed from what source the menstrual discharge flowed. Some affirmed, that it must flow from the vagina, and not from the womb, because it flowed sometimes during gestation. This is a fact which cannot be denied. I have attended a patient who menstruated during the entire period or to the eighth month; and I have often observed ladies to menstruate at the first period after conception. On the other hand, we have every proof of the discharge being from the orifice of the womb. For instance, some have observed on dissection of the parts of women dying during the flow of menses, that blood was effused under the delicate membrane of the cavity of the womb. The vessels there have

been observed particularly turgid, or the whole surface of the proper cavity, and especially the fundus, spotted with bloody effusions. More particular observation has shown not only the mark of blood poured out from the inner surface, but that the whole substance of the womb was become thick, soft, and vascular;* and M. Littre affirms that in the body of a woman who had died during menstruation, and with a conception in the Fallopian tube, he found a layer of red coagulated blood; upon removing which he saw a number of small foramina which admitted bristles.†

But the best and least equivocal proof is that which has been repeatedly observed in the inversion of the womb, when the inner surface has been turned out after labour, and has remained thus inverted, and protruding from the external parts, for then the menstrual blood has been seen to distil from the surface of the cavity of the uterus.

OF THE BLOOD-VESSELS OF THE WOMB.

THESE are four large arteries which supply the system of the womb, and four large veins which return the blood.

The SPERMATIC ARTERIES come down from the aorta itself, or from the renal or capsule arteries. The spermatic artery taking a waving direction, becomes tortuous in a most remarkable degree as it approaches the uterus: it is distributed to the Fallopian tube, the ovarium, but chiefly to the body and fundus of the uterus, where it forms remarkable anastomoses with the artery of the other side.

The LOWER ARTERY—the UTERINE ARTERY, comes in general from the hypogastric artery, takes also a serpentine course, and is distributed to the vagina, and the lower part of the uterus, and inosculates largely with the other vessels, both in the uterus, and by particular branches on the side of the uterus.

In the first place, it appears, that this copious supply of vessels to the uterus, from four different sources, is a provision that the womb and secundines shall not by any accident of position, or by the progress of labour and the consequent compression of one or both the lower vessels, be deprived of their due supply of blood. Again, their tortuous forms give proof of their occasional greater activity, that they admit of a pecu-

* The authorities upon this subject are Spigelius, Morgagni, M. Littre, Moriceau, Winslow, Sympson.

† This might have been an early abortion, or perhaps the decidua, which it is said is sometimes formed at the menstrual period.

liar and local action during menstruation, and that the blood will move more languidly when the stimulus of the womb has ceased. It is also a provision for the growth and increase of the womb, and the supply of nourishment to the ovum; and that an increased activity in a part must be supplied by a more tortuous form, as well as an enlargement of the calibre of the vessels, in a particular manner illustrated by the change which takes place in these vessels during pregnancy. For they become in a much more remarkable degree tortuous and enlarged.

The substance of the uterus is said to be spongy and compact, which though it is a seeming contradiction in words does yet really convey an idea of the effects of the intertexture of vessels in it. Some have said, (as Moriceau,) that by pregnancy the womb is distended, and grows thinner: others, that it grows thicker, as Daventer: and others again, as Smellie, assert, that it continues of its natural thickness. These assertions are none of them perfectly correct; for the womb is not distended by the growth of the fœtus and membranes, but grows with them. Again, that the substance of the womb grows in a remarkable degree is true, but still when distended by the waters in the last months of pregnancy, its walls are thinner than in the unimpregnated state. Thus, when it has been cut in the living body, upon the approach of labour, as in the Cæsarean section, I have observed it, not more than a quarter of an inch in thickness, even at the part to which the placenta adhered. When I have dissected the womb after a tedious labour, the waters discharged, but the head wedged in the pelvis, I have found it considerably thicker. And, lastly, in the full contraction of the womb, after expelling the fœtus and placenta, (for example, in rupture of the womb, where the child and placenta had been forced amongst the bowels, and the woman soon after died,) I found the walls of the womb more than an inch in thickness.

SECTION IV.

OF THE OVARIA.

The ovaria are two oval bodies which are suspended in the broad ligament behind, and a little below the Fallopian tubes: while they have an oval figure, they are somewhat flattened. By cutting out the ovaria, the animal loses the power of conceiving, and desire is extinguished; they, therefore, bestow what is

essential to generation upon the part of the female. In vague speculations on the subject of generation, they were supposed to prepare a female semen! but more particular examination demonstrates that they consist of vesicles which are ova; but how far incomplete, or in what essential circumstance requiring the approach of the male is not determined.

When we hold the section of the ovarium betwixt the eye and the light, we see a great many pellucid vesicles; and if we examine the ovarium of an animal killed in full health, and particularly in the season, we shall observe these ova to be in all varieties of states of preparation for impregnation. Some small and pellucid, and yet only discernible in the thick outer coat, by having a degree of greater transparency; others which have taken a slight tinge of bloody colour from vessels striking into them; and if the section be made after a minute injection, the vesicles will be seen coloured in the proportion of their maturity; some without a speck of colour; others tinged; one or two loaded with injection; and some vascular, and particularly prominent.

In very young girls, the substance of the ovarium is whitish, and very soft; the surrounding membrane is thick; and the round corpuscles scarcely discernible; and no irregularities, nor any of those bodies called corpora lutea, are to be seen on the surface. But as the girl advances in years, the little vesicles begin to appear, and when about ten years of age, or just before menstruation, the ovarium is full of ova of various sizes, and some of them more matured, and forming an eminence upon the surface. In the adult woman, the substance of the ovarium, which appeared as an uniform homogeneous mass in the fœtus, is become a cellular and vascular bed, giving nourishment to those numerous vessels or ova. Before impregnation can take place, there must be a certain state of preparation of the ovaria, without which, the approach of the male effects no change in the uterine system. The lower animals having their seasons, and these seasons being a state of preparation for the male, impregnation follows the copulation with much certainty; but, in woman, such a periodical revolution in the system, and instinctive desires, would but ill accord with that superiority in attributes of the mind, which distinguish us in the scale of beings. But women also suffer such an occasional excitement in the uterine system, though unaccompanied with desire, which preserves the womb in a state of preparation for the reception of the ovum, and the ovaria in a state of preparation for impregnation. This is the effect of menstruation.

OF PUBERTY.

Authors have long, with many expressions of surprise, laboured to assign a cause, or frame a theory, for the explanation of those changes which we observe in woman at the age of puberty: and generally, in their theories, they have connected with these changes the monthly and periodical discharges of blood from the uterus, which commences with puberty. These theories have been founded in general on principles remote from the laws of a living system. At this period of puberty the whole frame is expanded into the fulness of feminine beauty: the breasts rapidly increase, and are matured; the parts of generation are enlarged; the hair of the pubes grows, and the menses flow. In explanation of these changes, theoretical conjectures after this model have been entertained. "About this time the growth of the body begins considerably to diminish, and the blood finding easy admittance into the completed viscera is prepared in greater quantity, the appetite being now very sharp in both sexes, a plethora consequently follows. In the male it vents itself frequently by the nose, from the exhaling vessels of the pituitary membrane being dilated, &c.; and now the semen first begins to be secreted and the beard to grow. But, in the female, the same plethora finds a more easy vent downwards, being that way directed, partly by the weight of the blood itself to the uterine vessels, now much enlarged, of a soft fleecy fabric, seated in a loose hollow part, with a great deal of cellular fabric interspersed, which is very yielding and succulent, as we observe in the womb: for these causes, the vessels being easily distensible, the blood finds a more easy passage through the very soft fleecy exhaling vessels which open into the cavity of the uterus, as being there less resisted than in its return by the veins, or in taking a course through any other part; because, in females, we observe the arteries of the head are both smaller in proportion, and of a more firm resisting texture. The return of the same is, therefore, more slow, both because the flexures of the arteries, from the increased afflux of the blood, become more serpentine and fit for retarding the blood's motion,* and likewise, because it now returns with difficulty through the veins. The blood is therefore first collected in the vessels of the uterus; next it is accumulated in the arteries of the loins, and the aorta itself, which urging on a new torrent of blood, augments the force so

* I have shown that the tortuous arteries always form a provision for the occasional increase of the action and acceleration of the blood.

far as to discharge the red blood into the serous vessels, which at first transmit an increased quantity of warm mucus, afterwards a reddish coloured serum, and by suffering a greater distention, they at last emit the red blood itself. The same greater impulse of blood determined to the genitals, drives out the hitherto latent hairs, increases the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery," &c.

We cannot have trust in so weak a theory, we cannot believe in this plethora, produced by the diminished growth of the limbs; neither can we believe that congestion and plenitude are produced in the female system, from the deficiency of perspiration, from their more lax and weaker solids compared with man, from their indolent and sedentary life: for facts are in direct contradiction. The growth and completed function of parts at this particular age, is not to be explained by any theory so partially applicable; during almost every period of life, there are similar changes taking place in some one part of the body. Parts lie dormant, and are stationary in their growth, which at a particular and stated age of the animal, enlarge and develope themselves by a new and invigorated action. Observe how different the proportions of the fœtus are from those of the adult. We see nature careful to perfect certain parts, as the head and liver, at an early period. We see during early childhood how the parts shoot out, and evolve in due proportion. We see parts which were large in the fœtus lose their preponderance: we see others, which served some purpose in the fœtal system, gradually shrink and disappear, because they have no longer the stimulus to action in the circle of connections which take place in the adult system. We find other parts, as the teeth for example, lying long within the jaw, instead of proceeding with a gradual and continued enlargement, suddenly rising at certain stated periods from their embryo state, and enlarging and pushing up through the gums, when it becomes fit that the child should take more solid food than the mother's milk. So the second set of teeth, in a more particular manner, lie quite stationary in their growth within their little sacs, yet quickly, at stated periods, they increase, the enamel is formed, and they rise above the gum. There is an infinite number of such changes depending upon the same laws of the economy, and not different from those which control the growth, and direct the shape of parts. They depend upon certain laws of the constitution, which give an excitement to certain parts, at stated periods, and which no theory partially applicable will explain. There is a series in which the parts of an animal

body are matured, and a succession in which the functions are brought to maturity; and in the female constitution, there are laws determining an action upon the womb and breasts, and all parts subservient to conception and the nourishment of a fœtus; at that period when the woman is arrived at the age fit to take upon her the part of a mother.

OF MENSTRUATION.

Under this head, I shall confine myself to such a general view of the subject, as is necessarily connected with the peculiar functions we are now endeavouring to comprehend.

Menstruation is a state of preparation for conception. When, therefore, the menses flow at the natural periods, and in due quantity, it is a sign that the woman may conceive, and that her system is fit for the support and nourishment of a child. It is a general affection of the system, which has a tendency to relieve itself by a topical action, by the excited action of the uterine system; and this excitement of the uterine system is the end which nature is accomplishing. To explain this, I may be allowed to take a short preliminary view: each particular organ or viscus, whilst it has its connections with the general system, is, in truth, a system within itself, having its peculiar functions, sympathies, and even vascular action, in a certain degree independently.

Were not this in some measure the case, we should see no local disease or topical action; and no vascular action could be for a moment stationary and confined to one part. The body would, indeed, be then only one great hydraulic machine. But while the several parts have the property of being excited separately to an accelerated action, they are actuated by remote sympathies, and by these sympathies and relations is the whole system in a great measure supported.

Before menstruation commences, there is a preceding indisposition, and symptoms indicating a constitutional affection. And these complaints are usually more severe in the first than in the subsequent periods. The general revolution in the system begins to accumulate its action towards the womb, and those symptoms usually accompanying uterine irritation, show how far it is affected, and in a little time the menses flow. Now, I conceive the flow of the menstrual blood to be, not the end which nature is here labouring to accomplish, but the means of allaying the excited state of the uterine system, after the object is accomplished. It is not the discharge of a few ounces of blood which relieves the system; for drawing blood

simply will not do it; but it is the excited action of the uterine system which relieves the general distress, and that topical action has full relief in the menstrual discharge. General and topical plethora are terms which have been of great service in explaining this periodical change in the female system, but the state of mere fulness has little effect either on the constitutional or topical change. Even in the exhausted and debilitated state of the system, when menstruation ceases from the want of energy and power in the vascular system, still there remain the same laws governing the sympathies and relations of the several parts; and although they are feebly and imperfectly excited, they give rise to accumulated distress at the period in which the menses should flow.

With regard to vicarious hæmorrhagy from remote parts of the body, some, whose opinion I greatly value, do not consider them as deviations of the menses. At all events, from what I have seen of such hæmorrhagies (tumours, for example, discharging blood at the menstrual periods,) I would observe, that there is an excitement, throbbing, and distention, previous to the discharge of blood, which confirms me in the notion of the necessity of a counter excitement and action, as well as the discharge of blood, being necessary to make a derivation from the uterine vessels. It is by dissection alone that we can form a correct opinion regarding the final use of the periodical return of the menses.

By dissection we come to the knowledge of the most essential facts. In the first place it is found, that the ovaria, and their vessels, partaking of the general excitement of the spermatic arteries, are enlarged, full of blood, and with every sign of increased action. We find also, that the ovaria are matured and brought to pullulate, and almost to start from their investing membranes. Without the ovaria are in this state of preparation, conception cannot take place. In considering this subject of menstruation, the mere circumstance of the discharge of blood has been too much thought of, while the other more essential circumstance, the change upon the ovaria, has been neglected. The end of this periodical excitement is to ripen the ovum, the flow of menstrual blood to allay the excited state of the uterine vessels. Accordingly, if conception should take place, the excitement proceeds, and no flow of secreted blood takes place during the period of gestation.

It is not easy to determine, says Haller, either in this or in any other spontaneous hæmorrhagy, from what kind of vessels the blood flows. From the circumstance of the hæmorrhoidal discharge, which certainly is from veins, and from the lochia, which is generally supposed to be a discharge from the venous

sinuses of the womb after delivery, we have the argument of analogy, that in menstruation also it is a venous discharge. This opinion is further confirmed from stagnant blood being found in the uterine veins of women dying during the flow of the menses, and orifices being observed larger than could well be supposed to be the extremities of arteries.

I would say, that it is little probable that spontaneous hæmorrhagy proceeds from the rupture of the extreme arteries, because it is the activity of the arteries which causes the hæmorrhagy; and because this activity is the exertion of a muscular force, and the exertion of a muscular fibre never is such as to tear the fibre itself. On the other hand, we observe that it is the necessary consequence of an increase of the action of arteries, that the corresponding veins dilate, and seem to suffer a force of distention proportioned to their increased activity. We must not forget that many are of opinion, that the menstrual blood flows from the exhaling arteries. This opinion must rest upon argument, and not facts, unless the assertion of Rauw be taken as proof, that he could distinguish their mouths; or that of Meibomius, who said he introduced bristles into them. That anatomists have introduced bristles into pores, or foramina, it would be ungracious to doubt, but that these were the orifices of exhaling arteries, is difficult to believe. I rather imagine, that there is a provision for this evacuation in pores, or foramina, in the extreme veins on the vascular inner surface of the womb.

From the consideration of the cause of menstruation, as I have conceived it, from the symptoms which precede and accompany it, and from the effect attributable to the menstrual action on the uterine system, we cannot consider it as a mere evacuation of blood, but rather as of the nature of a critical discharge relieving the symptoms which preceded it. With regard to the opinion of its being a secretion, we must first know accurately what is meant by the term. If those who suppose the menstrual blood a secretion, mean only that the blood is changed by the action of the vessels of the womb, I should willingly acquiesce in their opinion; for even during the bleeding from the arm by the lancet, or from a common wound, the blood is altered in the space of the few minutes during which it flows; and before the final stopping of a common hæmorrhagy, there is a change in the properties of the effused blood.

When there is an unusual source of irritation in the womb, added to the natural and periodical excitement of the parts, the menses become more profuse, they last for a longer period, the time of their intermission is shortened, and, in the

end, from some diseases of the womb, there is a perpetual oozing of blood, which debilitates the woman, and destroys her constitution, or there is sudden and profuse discharge with coagula, unlike the usual evacuation.

OF THE CHANGE PRODUCED BY THE UNION OF THE SEXES.

In considering those changes produced on the ovaria and womb by impregnation, we must have recourse to analogy in the first instance. By attending to the changes produced in vegetables, and the lower animals, we may be enabled to comprehend such of the changes in the female organs consequent upon conception, and which we might not otherwise be enabled to understand.

We see that vegetables propagate their branches in every respect like the parent trunk. We see in the autumn the bud lodged in the axilla of the leaf, and observe it pass through the winter in a kind of dormant state; but when it is influenced by the returning heat of the spring, it shoots out to full maturity. This growth is a natural power of propagation and increase, marked by no very peculiar circumstances, yet bearing a strong analogy to the production of the seed.

In the formation of the fruit of the same tree, we see a more complicated provision for the propagation of the plant. We find that although the seed appears to be formed by the natural growth of the part like the bud, yet before it becomes prolific, and capable of growing, and arriving at maturity, it must be influenced by circumstances similar to the union of the sexes of animals; that its power of reproduction depends upon the reciprocal action betwixt the parts of the same plant, or by the approximation of male and female plants.

Between the formation, maturity, and impregnation of the seed of plants, and those of the ova of animals, there is a close analogy. The seed is formed and matured while attached to the parent plant; but the vessels of the plant having completed this operation, shrink from their connections with the seed, leaving it with its little system of vessels complete, and with a kind of imperfect life, which may be considered as analogous to a dormant state. This imperfect life, or perhaps a state merely capable of being excited into life and motion, continues for the winter season, or for a longer period.

The flower of plants solicits the fluids to the seed, as the influence of the leaf cherishes the bud in the axilla. The pulp of the fruit is probably a provision of the same kind, or when

it has fallen, to lay the foundation, by its decay, of a soil suited to the tender plant.

In the seed itself, we have much to admire. We find it incased in a strong husk, or shell, which is in general provided with a porous part ready to imbibe the moisture of the ground. In the nut within the outer shell, there is a soft spongy substance, which, receiving the moisture, swells and bursts up the shell, and relieves the seed. The kernel of the nut is then like a common seed, it has begun to vegetate, and these are the parts which form the system of its economy. The principal part of the seed consists of albuminous matter for the supply of the nourishment to the embryo plant, so as to prolong its shoots, and to send down its roots into the earth. The little embryo plant lies complete in all its parts, betwixt the lobes of albuminous matter, in a state of torpor, or in which the operation of the living principle is suspended. From the embryo plant there extends into the albuminous matter of the seed, vessels or tubes, inactive, but ready, on the supply of heat and moisture, to absorb the nutritious matter of the albumen, and minister to the increase of the embryo plant.

Now the root of the little plant sprouts from the seed, and has a tendency to strike into the ground, and the bud rises to the surface towards the light, and the influence of the atmosphere.

We see in this instance, that the operation of the system of tubes of the embryo plant in the albumen was merely suspended, that upon the seed being put into the ground, the heat and moisture promote the germination, by driving the nutritious matter of the albuments to the embryo plant. In the first stage of this change, the matter absorbed by the vessels of the albumen supply that nourishment, which afterwards is conveyed from the root striking into the earth, and from the leaves absorbing from the atmosphere. And when the roots have struck into the earth, and the first leaves rise upon the surface, the lobes of the albumen are exhausted and fade, or rise up in form of leaves, still cherishing the tender plants.

When we come accurately to examine the situation of the embryo in oviparous animals, we shall find the same provision for the nourishment and growth of the young animals, independent of external circumstances, nourishment prepared for it until it shall be enabled to gain strength to feed itself.

The manner in which an egg is formed is this: The yolk, with its delicate membranes, are formed in the ovarium of the hen. The ovarium is placed on the back-bone, innumerable yolks are seen gradually formed, and successively increasing in size. When they are matured, they are of the full

size we see them in the perfect egg; they are surrounded with a delicate web of membranes, extremely vascular, the membrane of the yolk bursts when it is mature and impregnated, and then it falls into or is grasped by the infundibulum, or what answers to the Fallopian tubes in woman and in quadrupeds. While yet in the egg-bed, the embryo is seen to be included in its membranes, upon the surface, or in the membrane of the yolk, it is called cicatricula; as the yolk, and the cicatricula, pass through the uterus, the yolk, in a most curious way, has the addition of the other part of the egg. The uterus of a bird is not like that of other quadrupeds or viviparous animals, simply for the reception of the ovum; but it is long and convoluted like the intestines. And the yolk, as it drops into the upper part of it, collects as it passes along the uterus, the white of the egg, which is a secretion from it. As it proceeds downwards, it receives the membranes of the white, and before it is excluded, it is coated with the shell to preserve it from injury when it shall be dropt from the hen. In the fully formed and incubated egg this is the situation of the parts. Under the shell is a membrane which invests the whole parts, but leaves a space containing air in the greater end betwixt it and the shell. Within this membrane the glairy white of the egg is contained, and within the white or albuminous matter is the yolk. Under the membrane of the yolk, there is a small spot of a lighter yellow than the yolk. This, upon examination is found to be a vesicle, and within it we see a lesser circle formed by an inner vesicle: this is cicatricula, and within this the rudiments of the chick are contained. We may observe, that the yolk is specifically lighter than the white; again, it is fixed, towards the two extremities of the egg, to the albumen, or white, by the chalaza. These are like twisted cords, which arise from the yolk, and expand in the white, so that they take a pretty firm hold on its tenacious substance. These chalaza are not fixed to the yolk in its axis, but to the side, so that the buoyancy of the yolk keeps it revolving as the egg is turned, so as always to present the cicatricula to the upper part of the egg, in whatever way it is placed; consequently it is always contiguous to the body of the hen, so as immediately to receive the influence of the maternal heat. By incubation, the principle of life in the chick and its membranes is roused, and the first perceptible change appears in little bloody streaks, which, running together, form a circle of vessels, and which are seen to terminate in the umbilicus of the chick.

This vascular circle, the most beautiful appearance of any in the economy of animals, ought to be particularly explain-

ed. In Mr. Hunter's book, treating of the blood, there is a plate which represents the embryo of the chick in the incubated egg, at three different stages of its formation, beginning with the earliest visible appearance of distinct organization.—The preparations from which these figures are taken, form part of a complete series contained in Mr. Hunter's collection of comparative anatomy.—They are meant to illustrate two positions laid down in his work, viz. that the blood is formed before the vessels, and when coagulated, the vessels appear to rise; that when new vessels are produced in a part, they are not always elongations from the original ones, but vessels newly formed, which afterwards open a communication with the original.

This to me seems an idea founded on a very limited view of the state of the parts. We must recollect that this is not the formation of new parts or new vessels. The embryo is in that state of which I have endeavoured to convey an idea, by the term dormant; possessing that degree of life which is to be renewed by incubation, or artificial heat, but which will last a great length of time, and, like the germ in plants, be brought to vegetate only in particular circumstances. The tract of these vessels is laid in the original conformation of the embryo and surrounding membranes; they are now merely called into action, and we see only the effect of this action. We see red blood formed; we know that the redness of the blood is derived from the membranes, and matter which surround the embryo, and that it is conveyed to the chick or embryo. Before we allow ourselves to conjecture what is the first motion in the circle of actions which now take place, we must consider whether it be not more likely that the first action of these vessels is in absorption; that is, an absorption in the extremities of these vessels, or is there first an action of the heart of the chick?—We are left to this question. Is it probable that a change shall take place in the fluids which shall stimulate the vessels? or shall the heat of incubation stimulate the vessels to act upon the contained fluids? or, as seems most probable, does the incubation, at the same time, produce a change in the fluids, and stimulate the vessels to action? To explain my opinion, I shall describe the probable series of actions.

In common seed the small germ of the plant has its vessels passing out into the lobes of the albumen to absorb the food, upon the existence of the peculiar circumstances necessary to its being stimulated to activity and growth. We have to observe, that where the nut was attached in its husk to the tree, it has left a porous part; by this cribriform kind of plate

the moisture of the earth enters ;—that dry scurfy substance which we observe on the inside of the shell, swells with the moisture, which also penetrates the albumen or kernel—the moisture forming a combination with the albumen prepares it for absorption ; the vessels are at the same time excited, absorb, and thus nutritious fluids are conveyed to the germ—the nut splits by the swelling of the parts, and the corculum or bud sprouts up.—We find then, that in this instance the grain, or nut, is brought into action by the fluids absorbed, forming new combinations with the albumen or kernel, and the active exertion of the living powers, beginning by an operation in the fluids.

In the same manner, I conceive, that the incubation of the egg causes an action first in the fluids, not in the solids (for these are solids according to the strictest signification of the term, and strong membranes, as a little vinegar will show, when poured upon the albuminous substance of the egg). A change takes place in the fluids, there are new arrangements suiting them for absorption, by those circles of vessels which are laid on the original formation of the membrane. The fluids act as a stimulus to those vessels, whose alternate action and relaxation never cease until the termination of life. I conceive this explanation, which I have offered, to be more consonant with the great principles of physiology, and an extensive analogy of similar actions in the economy, than that explanation of Mr. Hunter, which supposes the specks seen at the sides of the vessels, to be spots of coagulated blood, destined afterwards to become blood vessels. For, I am apt to conceive, the red blood to be formed only after several rounds of the circulation, and to depend upon a more perfect assimilation than that first excited : and that Mr. Hunter is all along in this mistake, that he is supposing these vessels to be newly formed, which are laid in the constitution of the membranes surrounding the embryo, and which are now only called into action, and only become apparent when they convey red blood.

In the system of the egg there are other circumstances worthy of notice : as the chick grows by the absorption of the white, or albumen, the new combinations reduce to a lesser bulk the whole mass, which is within the shell, and now we perceive the use of the air-cell, which enlarging fills up this space. When the chick has escaped from the shell, the yolk of the egg is not exhausted, but it is found to be received into the belly of the chicken, and to have a conduit leading into the duodenum, by which it is poured into the intestinal canal. It is for some time a source of supply to the young animal until

its strength is equal to the digestion of its appropriate food. And in this respect it is analogous to the suckling of viviparous animals.

Let us now observe what analogy exists betwixt the generation, or rather the birth and nourishment of the embryo of the viviparous animal, and those of the oviparous. As to the precise effect which the approach of the male has upon the ovarium of the female, whether, by this union of the sexes there is an actual addition to the ovum, or only an influence exerted on the parts already there by the presence of the male semen, it seems almost needless to hope for an absolute decision.

The resemblance of the offspring to both parents would influence us at once to conclude, that there must be a union of the parts from both sexes. But when we consider how much the peculiarities of individual animals depend upon certain peculiarities of action; how the constitutional predispositions must depend on the same peculiarity in the action of the vessels, since the doctrine of absorption teaches us, that of actual substance nothing is permanent, but all suffers an incessant revolution and change, we are forced to conclude that nothing can remain but certain peculiarities of action, and we may then come to allow, that the male semen merely influences the state of the parts already formed, and does not bestow an actual substance.

In the speculations on the subject of generation, facts and observations have been so very rarely attended to, that those which have been offered seem to have had a preponderance much beyond their real value. Thus the microscopical demonstration of animalculæ swimming in the semen of the male, has given birth to an idea that they were homunculi, which being introduced into the proper nidus of the female, grew up to man's estate. Though, where all is conjecture, and, perhaps, as no better explanation is to be offered, it may seem improper so directly to contradict any theory, still I must say, that this is, in my mind, the height of absurdity. To suppose an animal secreted along with the seminal fluid from the testicle of the male (and which, in all probability, is the production of stagnation and putridity,) to swim and be nourished in the male semen, and yet to hold that on being introduced into the ovaria, it changes from an active animal into an impalpable gelatinous-like mass, and, after a series of changes, grows at last to the maturity of a human being, is altogether beyond my comprehension.

The experiments made by the ingenious Dr. Haighton, throw considerable light upon these delusive speculations re-

garding the impregnation of the female. He found by experiments on rabbits, that upon cutting the Fallopian tubes, forty-eight hours after the coitus, the impregnation was equally obstructed as when he had cut them previous to admitting the male; it would appear that in these animals impregnation is by no means the instantaneous effect of the union of the male and female, but that it requires at least fifty hours; for, when Dr. Haighton cut the Fallopian tubes at that period, it did not prevent impregnation. Dr. Haighton proves, that the generative process is not an instantaneous effect, as we should very naturally suppose, but an operation requiring time. That the semen does not reach the ovaria during, or immediately after the coitus, is sufficiently evident; and it is still more so that the ovum is impregnated while in the ovarium, and not upon its descent into the womb, which is proved from the fœtus sometimes remaining in the ovarium, or tubes, and growing to maturity. Dr. Haighton supposes the semen only to affect the vagina and uterus, and that a consent of parts, or sympathy, is communicated along the tubes and ovary to the ovum; and that neither the semen nor the aura seminales reaches the ovaria. When we look abroad for analogies, however, and find the semen of some animals, as fishes, merely thrown out upon the already evacuated spawn, we cannot readily acquiesce in this opinion of the mere sympathy of the female parts calling the young animal into life.

Leaving this subject we have to observe, that previous to impregnation there is a ripeness and prominence of some of the ova, that by coition the Fallopian tubes do not instantly grasp, impregnate, and cause the bursting of the ovum from the ovarium; but there is an action commenced which gradually brings about this change. Whilst the ovary is thus affected, the tubes are preparing for their action of embracing the ovum, there is an increased turgescence in their vessels, and an enlargement and swelling of the fimbriated extremity. When thus prepared, it approaches the ovarium, grasps, and receives the ovum, and by a peristaltic motion, probably very slow and gradual, the ovum is conveyed into the cavity of the uterus.

OF THE OVUM, AND ITS CONNECTIONS WITH THE UTERUS IN THE EARLY MONTHS OF PREGNANCY.

THE ovum, when it has descended into the uterus, and is perfect in its structure, is a soft oval mass, fringed with vessels, and composed of membranes containing the early fœtus,

When opened, or dissected, it presents three cavities, or we observe the fœtus to be surrounded with three distinct membranes. The 1. Decidua, or tunica filamentosa, false chorion, or spongy chorion. 2. The chorion. 3. The amnios. Of these coats, the outer one is formed by the womb, the others constitute the ovum as it has descended from the ovarium. We shall, in the first place, attend to the original membranes and general constitution of the ovum, and then to the deciduous covering which it receives in the womb.*

Plan of the Membranes.

A, The Fœtus. B, The Amnios. C, The Chorion. D, The Vesicula Alba.

Amnion. The amnion is the vesicle which immediately involves the fœtus. It is a very thin and pellucid membrane in the early stage of pregnancy, but it acquires considerable thickness and strength in the latter months.

The amnion contains a thin watery fluid in which the fœtus is suspended. In the abortion of the early months, we find the quantity of this fluid very great in proportion to the whole ovum, and this forms a defence to the delicate and almost gelatinous substance of the fœtus, while it is a provision also for the regular presentation of the head of the child, for now the fœtus being suspended in this fluid, and hanging by the umbilicus, and the head and upper part of the body greatly preponderating, it takes that position with the head presenting to

* See Albin. Ann. Acad. lib. i. cap. xviii. and xix. Hunter's tables of the Gravid Uterus.—Camper Icones.

the orifice of the womb which is necessary to natural and safe labour, the fœtus being prevented from shifting in the latter months by the closer embracing of the child by the uterus.

Chorion. The chorion is the second involving membrane of the fœtus ; on the inside it is smooth, and betwixt it and the amnion a gelatinous fluid is interposed. In the early months it is much stronger than the amnios, but in the advanced stage it has come in contact with the amnios, no fluid being betwixt them. And in proportion as the amnios gains strength to be of essential service in dilating the orifice of the womb during labour, the chorion has relatively become very thin and weak. On the outside the chorion is shaggy and vascular, and constitutes those minute extremities of the vascular system of the ovum, which attach to the surface of the womb, or rather to the flocculent membrane which it throws out.

The umbilical cord. When we can first discern the fœtus, it is merely like an opaque oval body of the size of a common fly, and closely attached to the amnion ; but, by degrees, it recedes from it, and then we perceive that it is attached by the umbilical cord, which consists of the trunk of the vessels going out from the fœtus, and which distributed upon the chorion receive the supplies from the maternal system.

Now we perceive that the fœtal system which descends from the ovarium, is not merely a fœtus or embryo, but that this embryo, besides a system of vessels within its own body, is surrounded completely with membranes, and that from the vascular system of the embryo, there go out vessels, which being minutely distributed to the outer vesicle, or membrane, and actuated by the same heart which circulates the blood through it, our little corporeal system prepares for imbibing the due nourishment from the uterus.

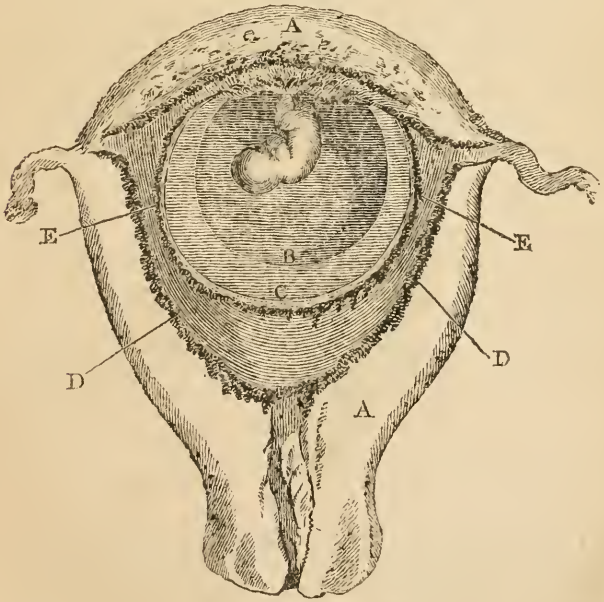
Vesicula alba. The vesicula alba, or umbilicalis, is a little vesicle which lies betwixt the chorion and amnion ; it contains a white fluid ; it is connected with the navel or cord, by an artery and vein. Very little has been offered as explanatory of its use ; it has been considered as similar to the alantoes of quadrupeds, and having a connection with the urachus ; but it has no communication with the bladder, and soon disappears. Whereas, if it had been for receiving the secretion of urine, it would have been prepared for the more mature state of the fœtus.

I conceive it not to be improbable, that it is a provision of supply for the embryo, previous to its perfect attachment to the uterine system, and during its descent into the womb, perhaps similar to the albumen of oviparous animals, but which

after the perfect establishment of the connection betwixt the fœtal and maternal systems, shrinks and disappears, as being no longer necessary.

OF THE ADDITIONAL MEMBRANES WHICH THE OVUM RECEIVES FROM THE UTERUS.

While the ovum is taking the changes consequent upon impregnation, the womb partaking of the general sympathy which prevails over the whole uterine system, suffers a change adapting it for the reception of the ovum. The first appearance of action in the womb is marked by a greater activity of the vessels, a swelling and softness of its substance. While on the inner surface there is an exudation, which, being converted into a spongy membrane, is peculiarly adapted for the reception and adhesion of the ragged and vascular surface of the ovum.

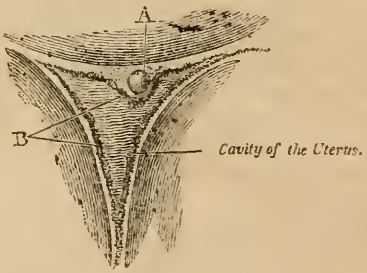


In this plan we shall be able to observe the relations and inflections of the uterine membranes or decidua, as seen and described by Dr. Hunter, and of their correctness, my observations in dissection leave no doubt in my mind. AA, the

uterus in outline; B, the amnion with the fœtus; C, the chorion. Now it is observed, upon a careful examination of an abortion of the early months, that besides the chorion and amnion, there is a spongy membrane of two distinct laminæ which invests the chorion. The outermost of these is found to surround the whole ovum, even investing that part which has become the placenta by the accumulation of vessels. This outer membrane then may be represented by the line DD. It is represented as adhering to the surface of the womb, as it must do in fact. We observe again, that it is perforated where the Fallopian tube enters the womb, that at this part it is not formed; so that, according to Dr. Hunter, and the preparations which I possess, these tubes open into its inside.

Upon dissecting up the outer lamina of the decidua, we find that where the placenta commences, it is reflected over the surface of the ovum and the shaggy chorion of the ovum, so as to be represented by the letters EE. We shall now understand the distinction betwixt the DECIDUA VERA DD, and the *Decidua Reflexa* EE.

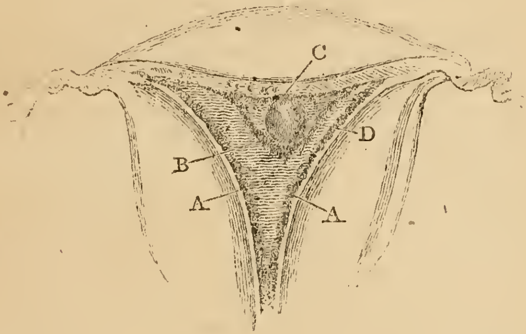
It would appear that this membrane is either completely formed, or at least the fluid which is to form it, is thrown out previous to the descent of the ovum; indeed, so intimate is the sympathy betwixt the whole uterine system, that this membrane is formed in those cases where the ovum does not descend, but constitutes the extra uterine conception.



Dr. Hunter supposed, that the ovum passed into the cavity of the uterus whilst the coagulable lymph was pouring out by the arteries of the uterus, and that it was thus immersed in and surrounded by the decidua, for he could not conceive that it could gain admission betwixt the lamina of the membrane already formed.

The only other supposition is, that the ovum A, upon its descent, gets entangled behind the deciduous membrane B, by

which means the ovum is not left loose in the cavity of the womb, but it is soon attached and surrounded with a membrane, or vascular web, from which it can immediately draw supplies, and by this provision also its adhesion to the superior part of the uterus is insured. But as the same action of the uterus continues, and, as we must naturally suppose, be rather occasioned by the presence of the ovum in its cavity, the surface of the uterus at A continues to throw out a coagulable matter which surrounds that part of the ovum, so that this will immediately become its situation.



A, The *Decidua Vera*, formed before the descent of the ovum. B, the *Decidua Reflexa*, formed by the ovum getting behind it and pushing it down. C, the efflorescence which continued to be poured out, surrounds the upper part of the ovum, and which, from its more immediate supply from the uterus, will in time form the sole support of the fœtus, viz. the uterine portion of the placenta.

OF THE PLACENTA, AND OF THE NUTRITION OF THE FŒTUS.

When the ovum first descends into the uterus, the fleecy surface of the chorion establishes a universal adhesion, but no sooner is the attachment of the ovum established, than the vessels of the fœtus which are universally distributed over its surface, begin to accumulate to that point from which the more abundant supply is obtained. Thus, from the universal adhesion, the vessels of the fœtus are massed and accumulated together, so as to form a thick cake or placenta. This takes place upon the same principle that the roots of a plant stretch towards the soil best suited to it, or the branches and leaves of

a plant grow and spread towards the light. The placenta is destined to adhere to the fundus of the womb, and there we observe the accumulation of the large vessels of the womb, it being equidistant from the several sources of blood; and to this point is the tendency of the vessels of the chorion so great, that we sometimes see the vessels of the chord running three or four inches upon the membranes before they reach the placenta, evidently showing that the point to which the umbilical cord had been originally attached, was not opposite to the more vascular part of the womb: but that the vessels had to stretch and elongate some way from the insertion before they accumulate in form of the placenta, towards that part of the uterus where there was the greatest vascularity.

But the formation of the placenta on the fundus of the womb is not constant, although there are many provisions for insuring attachment there. But when it does form low in the womb, or on the orifice itself, we then perceive the reason of nature's solicitous care in preventing it; for it occasions the most dangerous floodings from the placenta presenting on the approach of labour, and its connections being necessarily torn up previous to the delivery of the child.

The placenta of the advanced stage of gestation is a mass formed partly by the accumulations of the vessels of the fœtus (the trunk of which is the umbilical cord,) and partly of a vascular and cellular portion formed by the uterus. On the surface attached to the womb, the placenta exhibits deep and irregular fissures which divide it into lobes; but on the inner surface is smooth from the investing membranes, but raised into irregularities by the numerous and tortuous ramifications of the umbilical vessels. When rudely torn or cut into, it appears to be a spongy substance, formed in a great part of an irregular tissue of vessels.

In the human subject we find, that the maternal part of the placenta is thrown off with the other secundines, and does not separate from the fœtal part of it. While, in other viviparous animals, the monkey excepted, the filamentous extremities of the fœtal vessels separate from the glandular mass formed by the maternal vessels of the uterus.

The placentary vessels of the fœtus never touch the surface of the womb, but communicate with the maternal system through the vessels of the womb, which pierce the deciduous membrane. Still the question of the precise manner in which the vessels of the fœtus communicate with those of the mother remains undetermined. I conceive that in the early stage the deciduous membrane being thrown out by the action of the uterine vessels, those of the chorion stretch into it, and absorb

the nourishment. The decidua is a vascular membrane, but it has, at the same time, a peculiar spongy texture. This spongy or reticulated structure of lamina of the decidua ceases where the placenta is affixed. When we carefully dissect up the decidua to the margin of the placenta, it is found to be more rigid, white, firm, and thick.* When we examine the outside of an entire ovum, we observe that at the place covering the placenta, it is corrugated and full of irregular eminences like the convolutions of the brain, and amongst those irregularities many small convoluted arteries may be discerned, with spots of extravasation and the flat mouths of veins. Upon dissecting up this maternal part of the placenta, we find it to form the firmest part of it; and by the difference of colour, as well as by the possibility of tearing it up, or dissecting from the mass of vessels of the chorion, we recognise it as the decidua. This union, however, betwixt the maternal and fœtal parts of the placenta is intimate, and it is impossible to determine by dissection with the knife, whether there be inosculations betwixt the maternal and fœtal vessels, or whether the nourishment of the fœtus is by absorption, nor can we distinguish in the first months the cellular intertexture which may be observed in the placenta of the full time, as described by Mr. Hunter.

In explanation of this part of our subject, I have purposely dissected, and made drawings of the ovum in several stages.

OF THE LIQUOR AMNII, AS CONDUCING TO THE NOURISHMENT OF THE FŒTUS.

Some physiologists, observing the strict analogy which exists between the function of the placenta and the lungs of breathing animals, have conceived, that the liquor amnii is the source of nourishment, and that it is taken into the stomach. I believe they have conceived some analogy to exist betwixt the albumen of the egg and the liquor amnii, which in their minds has strengthened this opinion. But there is here no analogy; we have seen, that the embryo of oviparous animals being formed with the yolk in the egg-bed or ovarium, descends into the uterus, and there receives the addition of the albumen or white. On the other hand we find that the ovum of viviparous animals is formed in the ovarium; and that the liquor amnii being within the membranes of the ovum, must be the production of the fœtal system. Further, when the ovum has

* I speak after dissecting the ovum of the third month.

descended into the womb, and grown to some maturity, we see that there is no connection by vessels betwixt the fœtus and mother but through the placenta; that the liquor amnii is within the involving membranes of the fœtus, and that consequently it must be thrown out by the vessels of the fœtal system. Thus, to suppose the fœtus to be fed by the liquor amnii, would be to suppose it to draw resources from its own system, and that the vessels poured out a fluid, which is afterwards to be taken into the stomach.* But without adducing arguments, it is sufficient to say, that fœtuses have been brought forth, monstrous in their conformation, and without mouths, yet well grown.

Of the placenta as the source of nourishment to the fœtus. When we consider the mere speck of the embryo in the first weeks, we see that it can have no other source of nourishment than through the extreme vessels of the chorion, connected with the short umbilical cord; and we may be convinced also, that in its progress to maturity, when the general connections of the chorion cease, and the placenta is formed, the sole supply is through its vessels. Regarding the manner of the communication betwixt the vessels of the mother and child there are many opinions. The simplest explanation, but the furthest from truth is, that the arteries of the womb are continued into the veins of the fœtal portion of the placenta. That on the other hand, the arteries of the fœtal system are continued into or inosculate with the veins of the womb; and that thus the blood of the mother's system is carried by direct inosculation.

A little investigation will convince us, that this is a very unlikely conjecture. We see the embryo surrounded with its vessels, and forming a complete system within itself, descend into the womb. We see that the attachment betwixt the surface of the ovum and the womb, depends on a reciprocal action betwixt them; and when the fœtus is feeble, or diseased, or when it dies, the uterus immediately separates from it, as from a dead part, and there is an abortion. Again, it is not natural to suppose, that the circulating fluids of the adult are calculated for the circulation in the embryo, or that the blood of the adult is fit for the circulation of the fœtus. When we inject the vessels of the fœtus, we find the veins and arteries of the umbilical cord to inosculate freely with each other, and the fluid passes from the arteries to the veins with little extravasation or escape of fluid, and such only as may be supposed to

* A greater absurdity than that of which a foreign author is guilty cannot be imagined: because the liquor amnii, or some fluid, is found in the trachea, he supposes that the fœtus respires, and receives oxygenation from the liquor amnii.

pass from torn vessels. Again, the bleeding of the child does not draw from the maternal system; for example, when the accoucheur has to perform the operation of embrioulcio, and when the arteries of the brain pour out their blood, the woman does not suffer, nor is there any danger of hæmorrhagy from the cord after the delivery of the child. Again, what does the analogy of other animals show us? We may observe, in the first place, that probably on account of the peculiar form of the womb of woman, and in these circumstances to guard her from danger of hæmorrhagy during delivery, it is necessary that the placenta should be accumulated towards the fundus of the womb. Now, to allow less danger of the separation of the secundines from the womb, and consequent abortion, there follows a necessity for the human placenta being attached in a particular manner: and in place of the maternal part of the placenta remaining with the womb, as in other animals, the whole mass separates on the delivery of the child. The necessity for this firmer attachment of the human placenta, causes the connection betwixt the fœtal and the maternal portions to be very intimate, and the manner of the vascular connection by no means easily demonstrated.

In other animals, however, for example, in those which have the small and numerous placenta, or cotyledons, the fœtal and maternal portions of the placenta separate easily; the maternal part being a prominent vascular bed, which is a part of the womb, and is not deciduous. Here we find, that the glandular-like portion which belongs to the womb may be minutely injected, and no particle of colour pass into the fœtal part: and again, injection shows the fœtal portion to be merely composed of the fleecy extremities of vessels, which, however minutely injected, do not show any inosculations with the maternal vessels; in short, here the connection betwixt the extremities of the two systems is so very loose, and the filaments so minute, and almost like an impalpable mucus, that we can imagine no other kind of connection than that the extremities of the umbilical vessels take up by absorption the nutritious matter necessary for the system of the child, and that this is secreted by the vessels of the womb.

Investigation in every department of natural history shows a similarity and a simplicity in the operations of nature. Comparative anatomy may be brought with much advantage in illustration of the very obscure laws which guide the functions of the parts of generation. When we turn our attention to the egg, we find, in the first place, that the vascular system is complete within itself, and requires no permanent connection with the maternal system to invigorate its action. We find that the

artery which passes out of the umbilical cord of the chick, and which is distributed to the membranes of the white, pulsates strongly, and carries venous-coloured blood. We find the returning vein carrying arterial-coloured blood. We find then that these vessels must have a double function; they imbibe the nourishment from the white, and convey it to the increase of the chick; and they at the same time perform an action similar to that of the pulmonary vessels of the adult, seeing that they carry out dark-coloured blood, and convey it back to the chick, of a bright vermilion colour. Now, I do not conceive that this change upon the blood is performed by the communication of the atmosphere through the shell, for I see no distinction in the colour of the vessels, which are contiguous to the membrane of the shell, and those which are removed from it by the expanding of the air-cell. Further, we find, that there is an intermediate kind of generation in fishes which are oviparous, but retain the egg within their womb, until the fœtus is matured; here no communication with the air or water can be allowed.

Since we see that the chick in ovo is capable of ministering in every essential particular to its own increase, wherefore should we suppose that the fœtus of viviparous animals has any other more particular connection with the womb of the mother?—The difference is in my mind this simply; the ovum of the oviparous animals descending through the convoluted and intestinal-like womb of the hen, accumulates a quantity of matter around it, which serves every purpose of nutrition when the embryo shall be finally separated from the maternal system; but in the viviparous animals the ovum descending into the womb remains there, and has an incessant supply of nutritious fluid, secreted from the vessels of the womb, as it is required by the appetency of the fœtal system. As in the egg, the membranes surrounding the white have the same effect upon the blood, which is afterwards produced by the lungs; so has the placenta of viviparous animals the double function of supplying nourishment, and the purifying of their blood. The umbilical vein carries back pure arterial blood, and the common opinion is, that the blood of the fœtus coming in contact with the blood of the maternal system, receives the principle from it, which bestows this quantity of colour, with other necessary qualities, of which this of colour is but the sign to our observation; or we may say that the carbon of the fœtal blood is imbibed by the maternal blood; and in this way the blood of the fœtus is purified. It is not necessary to this change on the fœtal blood, that it should come in immediate contact with the maternal blood, for it is possible, that the matter thrown

out by the maternal vessels, whilst it is nutritious, has also in it, in a condensed and not a gaseous form, that which is essential to the change of the blood of the fœtus from the modena colour to bright vermilion.

OF THE EXTRA-UTERINE CONCEPTION.

We find some curious facts relating to the action and sympathy amongst the parts of generation, proved by the cases of extra-uterine conception, where nature, baulked and interrupted in her usual course of operation, shows unusual resources. It would appear, that the ovum, after impregnation, has, in some cases, remained attached to its original seat in the ovarium, perhaps owing to some want of due sympathy and synchronous action of the Fallopian tubes, which should grasp and receive the ovum. In other instances the ovum has been received into the Fallopian tubes, but either from a want of sufficient dilatation and action in them, they have not been able to propel it forward, or the ovum, taking upon it that action which is destined to form its connections with the uterus, adheres, and is enlarged in the tube, so that it cannot be conveyed down into the womb.

I am not so fully satisfied of that kind of extra-uterine conception, where, after impregnation, the ovum has dropt from the ovarium, and lies in the cavity of the abdomen amongst the viscera. Here it is supposed the vessels of the fleecy chorion spread, and attach themselves to the surface of the viscera.

These instances of deviation from the natural action of the parts after conception prove to us, I think, that from the moment of impregnation there is a principle of life and activity in the system of vessels of the ovum, and that at a stated period this action becomes such, that the efflorescent vessels of the surface of the ovum attach themselves to whatever vascular surface they are in contact with. Further, it seems to show, that in the womb, and in the deciduous membrane which it prepares for the reception of the ovum, there is nothing very particularly necessary, and that any vascular surface will take upon it the same changes, and being excited probably to some peculiarity of action, will in every thing essential supply the growth and nourishment of the ovum and fœtus.

It shows us how far the action previous and consequent to impregnation is a universal and sympathetic excitement of the uterine system; that the decidua is formed in the cavity of the womb, although the ovum does not descend. This points

out to us how careful nature is, that there shall be a reciprocal action in the ovum and womb, so as to insure the adhesion of the ovum, and the ready supply of a proper nidus for it, when it shall have descended into the cavity of the womb. It informs us, that the uterus is a spongy and vascular bed, having peculiar sympathies which actuate its vessels, and a form of vessels adapted to quick acceleration of action so as to grow, enlarge, and supply the secundines with nourishment.

It is not, however, in the mere adhesion and supply afforded to the fœtus, that the peculiar adaptation of the womb for the reception of the fœtus is shown, but in the provision for the delivery of the child at a regular and stated period. For, it is a curious fact, that in the case of extra-uterine fœtus on the expiration of the nine months, the uterus takes upon it that action, and that excitement of its muscularity which is destined to expel the fœtus. We find, that at the usual time of uterogestation, there are pains excited, and flooding, with the discharge of the decidua from the womb, although it contains no fœtus.

Nay, further, it would appear from the result of several cases, that at the expiration of the natural term of uterogestation, the fœtus indicates that it is governed by prescribed laws, which render a change necessary, and show that its system is no longer fit to be supplied through the placentary vessels, and as in the situation of extra-uterine fœtus this change cannot take place, it dies and becomes with its secundines as a load of foreign or dead matter in the belly. This event is generally followed by the death of the mother, though sometimes an abscess has opened and discharged the fœtus, or after much suffering, the bones have been discharged by stool, at long intervals.

OF THE WOMB AT THE FULL PERIOD OF GESTATION, AND OF DELIVERY.

To complete this view of the female parts of generation, it remains only to speak of the state of the parts at the full term of nine months, and to observe the process of a natural delivery.

The rapid increase of size of the pregnant womb in the short space of nine months, is perhaps the most surprising phenomenon of the whole animal economy; it shows the power of a peculiar excitement in calling into action a partial and local system of vessels. This state of pregnancy is the furthest from a state of distention, insomuch, that it is observed

the womb feels peculiarly soft on impregnation, and as if but imperfectly filled by the ovum. This soft state is a sign of vascular action. We may often observe in the discussion of a tumour, that before any change takes place, it swells and becomes soft, and this even where the tumour is about to be absorbed.

The fundus of the uterus is the part first enlarged; and afterwards the inferior parts; at length the cervix is obliterated, and the uterus, which was originally pyriform, becomes nearly oval, and the distention, as we have remarked, is greatest on the back part of the womb. In the first months the uterus sinks lower in the pelvis, they say from its weight, but the specific weight of the uterus is not increased, and on that account it should not sink deeper; it is, perhaps, rather from its enlargement, and the difficulty with which the fundus makes its way among the viscera in the brim of the pelvis. Having descended considerably, the os tincæ projects further into the vagina, but the fundus continuing to enlarge, at last emerges from the circle of the bones, and then from the conical form of the uterus, it sometimes rises suddenly out of the pelvis; now the vagina will be found elongated, and the os tincæ removed from the point of the finger.

Now the ligaments of the womb direct it forward, and it rises close upon the abdominal paries, and before the bowels; in the first pregnancy it rises almost directly up; in subsequent pregnancies, from the greater relaxation of the integuments and the abdominal muscles, it is allowed to fall more forward; about the fourth month of pregnancy, the womb may be felt in the abdomen, and rising out of the pelvis; in the fifth month the fundus is about half way betwixt the pubes and navel; in the seventh, it is about half-way betwixt the navel and scorbiculus cordis; in the eighth, it is at its highest, and towards the end of the ninth month, it rather subsides. Finally, immediately before labour it descends remarkably, and shifts into the middle of the pelvis, so as fairly to present the orifice of the womb.

The muscularity of the uterus is increasing from the first moment of pregnancy. As the uterus increases in thickness and is distended, the muscular fibres become more distinct, and their power of contraction greater; but what is very particular is the great muscular efforts made by the womb during labour by these fibres, which have not till that time felt the stimulus to action, or been allowed to contract.

When the period for the approach of labour is arrived, the nature of that viscid secretion which seals up the orifice of the womb is altered; it loses its viscidity, and all the parts are re-

laxed and prepared for the transmission of the head; even those rigidities, strictures, or callosities of whatever kind, which would seem to promise an absolute obstruction to the passage of the child, yield and relax previous to labour. The action of the womb is at first feeble, as might be expected, and accoucheurs have marked these stages of a natural labour.

1st. The womb has suffered no diminution of its size; the membranes are entire, and, of course, the contractions of the womb are feeble, because before it is allowed to make some contraction its efforts are not strong. This is a provision for the first stage of labour being slow; by and bye the orifice dilating, the membranes with the waters are felt protruding. The membranes and water is as a soft conical cushion, gently dilating the passage; and in this stage there should be no officious interference. While the membranes are entire, both the mother and child are in perfect safety.

2d. The orifice continuing to dilate, and the efforts of the womb increasing, the membranes burst, and the head of the child presses on the orifice; then the womb is allowed to contract; this contraction is a stimulus to greater efforts, and in a few pains, the head descends into the cavity of the pelvis. The orifice is completely retracted, and there is no longer a mark of division betwixt the womb and the vagina; they are as one canal. If, however, the membranes are burst too early, the labour is not accelerated, but retarded. The orifice is not dilated by the soft and elastic membranes; the head of the child presses broad on the orifice, which becomes rigid, and perhaps inflamed, its dilatation is slow, and the labour tedious. Though from the form of the bones, and particularly by the retiring of the sacrum, there is a provision and guard for the soft parts of the mother against compression by the head; yet nature intends this stage to be short, for it is the period of danger. There is now obstruction of urine and fæces, and the vessels of the parts suffer compression.

3d. Now the head of the child presenting at the orifice of the vagina, forms a third stage; it is the stage of most exquisite suffering: the head is pushed forward during every pain, and recedes again in the absence of pain. An interval of rest precedes this stage, at last the pains return, and the hard head of the child coming to press on the orifice, and the womb coming in close contact with the body of the child, the pains are redoubled in strength. The face of the woman, perhaps, before pale and flat, becomes red and turgid, the eyes gleam, and are inflamed; the pulse becomes quick and hard; and from the exquisite expectation of relief, she looks wildly

round on her attendants, losing all reason and recollection ; she is frantic, with the most agonizing pain to which the human frame is subject. Now the occiput of the child begins to project with its wrinkled scalp through the external parts, but nature intends that this also should dilate slowly ; the ligaments and os coccygis resist several throes, and direct the head forward under the pubes ; at last, after several pains, it rises with a half turn, and is delivered.

4th. The fourth stage, is the delivery of the body and shoulders ; and,

5th. The fifth stage, is the delivery of the placenta. The placenta is expelled by a continuation of the same action of the womb, and is part of the natural process. First a flow of the liquor amnii and blood follows the child, and the woman lies for a time exhausted ; the extreme pain and excitement having ceased. The womb generally recovers its powers in about twenty minutes, and then there is grinding pain in the belly, and the placenta is detached and expelled, or is pushed down into the vagina.

Thus we have sketched, in the most superficial manner, the progress of a natural labour, with a view merely to explain the general notion of the entire function of the womb, not with that minuteness which the accoucheur would look for in treating the subject. Let us for an instant, attend to the state of the umbilical cord, and the final contraction of the womb.

I have already observed, that while the membranes are unbroken, the child is safe, that is to say, there is no danger of the compression of the umbilical cord ; but when the membranes have burst, and the waters are evacuated, the cord must suffer a degree of compression betwixt the uterus and the child, and there is danger that the cord may fall down before the head, until the head has decended into the brim ; as the uterus contracts, and as it were follows the child, the circulation through the placenta must become somewhat difficult, and the usual function corresponding with that of the adult lungs impaired. This must be much more the case when the child is delivered, and the placenta remains in the contracted womb. No doubt nature intends by this, that the function of the placenta shall be gradually diminished, and not suddenly cut off, that the child may feel occasion for the play of the muscles of respiration, and that the functions of the lungs may, by degrees, take place of the function of the placenta. When the child is first delivered, the cord pulsates strongly ; when the child cries, it becomes feeble ; at first, the child has strong and irregular catches of the respiratory muscles, but by and bye it breathes more regularly, and cries lustily. At first the breath-

ing only renders the pulsation of the cord feeble, but presently the pulsation becomes so weak that it is felt only near the umbilicus, and it ceases when the regular and interrupted breathing is established, and the crying ceases.

The delivery of the child and placenta is followed by a considerable efflux of blood. But after this there continues a discharge from the uterus which is called the lochia. It is like the exudation of blood from an extensive wound, in as much as by the contraction of the vessels from which it flows, it becomes serous in a few days, and ceases gradually like a hæmorrhagy.

This open discharge from the womb after delivery, is no doubt a provision against the consequence which would naturally result from the sudden and perfect obstruction and the activity of the uterine vessels consequent on delivery. By this discharge the activity of the vessels is gradually relieved, and as it is a discharge taking place of the active state of the womb, so the secretion of the milk in the breasts, and the giving of suck, causes the discharge to cease much sooner than it would do if the mother were not the nurse.

OF THE MAMMÆ.

In man and in children of both sexes, there is no mark of the breast, but the little cutaneous papilla, or nipple. These tubercles, are, however, surrounded by a zone or disk, of a brownish red colour, the areola.

At puberty, as we have said, the breast of the female becomes protuberant, and those parts which were in miniature, and without action, quickly grow into a firm glandular mass. The shape, rotundity, and firmness of the gland depends much upon the adipose membrane surrounding and intersecting the glandular body.

The glandular part itself is divided into little masses, which again consist of small granules. These several subdivisions of the glands are closely surrounded by membranes.

The lactiferous ducts are gathered together from these lesser granules, and unite into 12 or 15 in number of a very considerable size, as they converge towards the root of the nipple. When milk is secreted, the glands are large, a remarkable distention of the ducts also takes place, for they are then become tortuous and varicose, and serve as reservoirs of the milk. Where they pass through the nipple, however, they are again contracted, and open by small pores upon its surface. The nipple is of a spongy and elastic nature, and suffers a disten-

tion or erection. When the nipple is contracted, the lactiferous ducts must be compressed, and perhaps coiled together, so that the milk cannot flow, or flows with difficulty; but by the sucking of the child, the nipple is distended, and the ducts elongated, so that the milk flows. There open upon the areola several superficial or cutaneous glands, which pour out a discharge to defend it and the nipple from excoriation.

Of the arteries, veins, or lymphatics of the mammæ, we need not treat here.

We have many occasions to observe the consent and sympathy which exist betwixt the womb and the breasts. On the first period of the menses, the breasts are much distended. In many women at each return of the discharge, a degree of swelling and shooting pain is felt in them, and the enlargement and shooting pain in the breast, with the darker colour of the areola, is marked as the most prominent sign of pregnancy; with the ceasing of menstruation, which is the cessation of the usual excitement and action of the womb, the breasts contract and are absorbed. Any unusual stimulus or irritation in the womb, as polypus, or cancers, or even prolapsus and excoriation, will affect the breasts, causing them to enlarge and become painful.

When the function of the parts ceases, they seem to feel the want of the usual excitement to correct action, and are apt to fall into disease; so it is at least with the womb and mammæ, for at that period of life, when the system is no longer able to support and give nourishment to a child, and these parts subside from their usual action, they often become scirrhous or cancerous, and terminate existence by a tedious, painful, and loathsome disease.

THE END.

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